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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTION OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

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Mr. Cook's American Exchange Paper.

The written discussion on Mr. Cook's paper on American *versus* British Cast Iron, which we printed in our issue of July 20, is most illuminating. The strongest support for Mr. Cook's assertions is given by Mr. Steven B. Phelps, of Pittsburgh, who, whilst pointing out that the paper contains many statements that American foundrymen and engineers know to be incorrect, if it is inferred that the castings cited represent standard American practice, finishes up his remarks with an apologia, blaming war conditions. Mr. H. J. Young, of Wallsend, who assumed Mr. Cook ascribed the superiority of British castings to inherent properties, as usual did not deny the possibilities of these qualities in pig-iron, but emphasised the fact that he still awaits proof and points out that he can reproduce a definite quality of casting by using a considerable variety of brands of pig-iron, based on chemical composition. As is well known, Mr. Young will not admit of stabilised cupola conditions, and undoubtedly there are factors which are beyond control, such as moisture carried in with the blast and the maintenance of the height of the bed from the beginning to the end of the blow. Control of casting temperature and rate of cooling down undoubtedly present other difficulties. But in spite of this, Mr. Young asserts that he himself would, with the greatest confidence, undertake to prove it (that Americans could produce castings of a grade equal to British) without any question of pig-iron possessing or not possessing inherent qualities.

Dr. Moldenke's criticism lends support to Mr. Cook's conclusions in so much as he points out that Germany (and for that matter most European countries) buy British irons when they require high-grade material. Here, inherency spreads to commerce, for we have every reason to believe that the Germans are fully alive to mixing by analysis. They, too, during and just after the war, "struck a bad patch" in their foundries, their trouble being hard white spots. Always in conversations of this nature the question of oxygen and gases comes up for consideration, but really, in the present state of our knowledge, oxygen and inherent properties are on a par, that is, little or nothing scientific is known about either. Dealing with mechanical testing, Dr. Moldenke states that he is puzzled at the summary of British practice as presented by Mr. Cook. His actual words are: "With us here, the Keep method is considered so antiquated that it may only be found sporadically in stove shops as yet. With all due respect to the attainments of Mr. Keep, whom many of us remember, and whose friendship we valued highly, none the less his usefulness as a guide ended when he refused to adjust himself to the, for him, uncomfortable facts brought out by foundry metallurgy. Possibly it is this study of cast iron in the light of the engineer rather than as engineer and metallurgist that makes me wish that Mr. Cook had explained why Britain still uses square and flat bars cast horizontally rather than round ones cast vertically. You have only to do as I have done—slice the flat bar into three, longitudinally, and test each unit, to see how different the metal at the corners and the edges is from that in the middle. We have still one branch of the foundry industry using a flat bar, and this industry is now considering the advisability of getting up to date."

With regard to this last phrase, we would revert to a statement in Mr. Young"s discussion. He says: "It has long been the writer's opinion that the greatest stumbling-block to America's progress in ordinary grey cast iron is their tapered test-bars cast separately." With regard to his remarks about Keep we would point out that it is the opinion of some brilliant foundrymen that this investigation spoilt some of his work by modifying his diagrams to make them fit in with another research worker's conclusion. Mr. Ronceray has dealt with this in a communication on Mr. Cameron's paper on semi-steel, which is dealt with elsewhere in our next issue.

MR. D. M. MOWAT, general manager of the Summerlee Iron Company, Limited, Coatbridge · Mr. William Graham, furnace engineer: Mr. William Howat, furnace manager; and several of the men were severely burned as the result of an ignition of gas on the top of No. 3 furnace at the Summerlee Works.

The Metallurgy of Semi-Steel.

By David McLain.

The author may be thought to be presumptuous and egotistical in daring as an American to address Britishers on the science of melting iron and steel or wrought scrap in cupolas, as some have been doing it very successfully for years, but please remember there is no more electricity in the world to-day than there was years ago, and until someone recognised the law by which it could be made of service, we knew but little of it. To-day the world is lit up by it. Just so as with the laws governing the science of melting steel scrap in cupolas, it took someone to prove that (1) steel scrap will *not* reduce total carbon; (2) steel scrap will *not* cause hard spots; (3) manganese is *not* a hardener; (4) high blast is *not* required; and although the author demonstrated all this twenty or more years ago, many writers to-day still claim steel will reduce carbon, and that is the main reason for the author's presence in Great Britain.

Writers for technical papers have advised foundrymen that it is necessary to use cold-blast pig, hematite pig, cerium, titanium, vanadium and other alloys if they want to make quality castings.

Others have also been advised to melt iron in the electric furnace, the air furnace, and the open-hearth furnace, and that quality iron, semi-steel and steel can be made in the electric furnace from cheap borings and turnings, but the cupola, in the hands of competent operators, can produce quality metal using steel and wrought scrap and other materials.

The cupola is considered a mysterious piece of equipment by many, who compare it to a bucking horse. They pose as authorities, but they "let George do it," and if the metal is good they take the credit, but if it is of poor quality they blame George for it.

Potentialities of Semi-Steel.

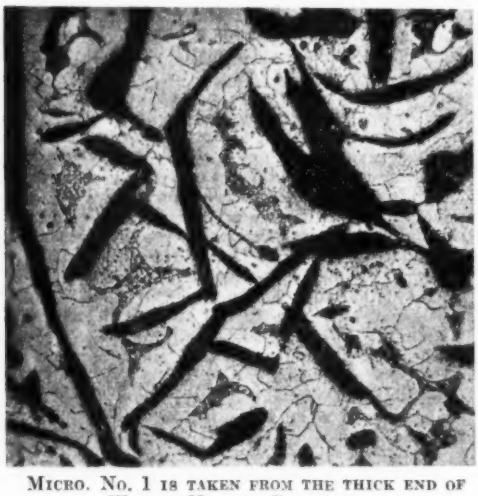
We believe this subject should be discussed to a satisfactory conclusion, as engineers and foundrymen throughout the world are guided by writers who should know that good semi-steel of ½ in. section is stronger and will resist hydraulic tests better than the average grey iron of 1-in. section.

Initially it may be as well to submit a few facts concerning the absorption of carbon by the steel from coke. When a boy the author learned that steel absorbed carbon from a facing sand containing coke. Open-hearth steel of 0.20 to 0.30 per cent. carbon poured in gear blanks made of this facing were considerably higher in carbon on the exterior than the interior.

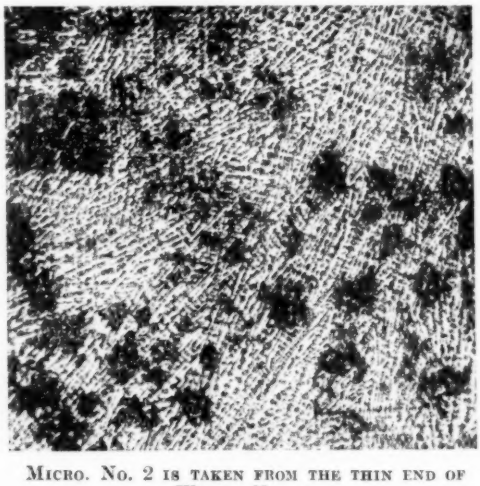
Taking advantage of this knowledge, the writer made tramcar wheels, using this coke facing on the tread, and after outwearing several sets of grey iron wheels, a large order was placed for similar wheels, being designated on the specifications as "chilled steel wheels." A steel rod in a blacksmith's fire showed signs of melting one day, and investigation proved that that rod had been in the fire frequently, absorbing carbon each time, until eventually the melting point was lowered to that of grey iron.

The ancients learned that a lump of iron ore thrown on an open fire, heated to redness and hammered, would develop into a spongy mass of iron that could be hammered to form implements of war, and modern chemists have analysed swords made by the ancients, finding there was 1 to 2 per cent. carbon present, this proving conclusively that wrought iron or steel will absorb carbon when heated in the presence of a carbonaceous fuel, so the writer experimented with coke and steel scrap in cupola mixtures, and was agreeably surprised to learn that steel will absorb up to 3 to 5 per cent. carbon, depending on the melting conditions. Synthetic pig-iron would be impossible except that the steel turnings absorb carbon from the coke.

Making semi-steel, like other things, depends on knowing how. Take Hadfield's process of producing manganese steel. Without his formula and instructions, the "man in the street" could not make it. The author has met many who tried to make manganese steel, but failed in the attempt. Should manganese steel be condemned on that account? Similar conditions exist with semi-steel. Some people try to make it without the proper instructions, and the resultant metal being full of hard spots or blow holes, they condemn semi-steel. One converter steelfounder may make good steel using 60 to 90 per cent. steel scrap, because he knows how to melt it and control the sulphur, while his competitor may use 50 per cent. pig-iron and still be unable to meet the specifications.



MICRO. NO. 1 IS TAKEN FROM THE THICK END OF WEDGE NO. 1—CAST-IRON.



MICRO. NO. 2 IS TAKEN FROM THE THIN END OF WEDGE NO. 1.

The magnification in all the micros. is the same—150 *dias.*

Rapid Advance in Metallurgy.

For 50 years previous to the time it was discovered that carbon is absorbed from coke when making semi-steel, very little progress was reported by grey iron foundrymen.

The greatest developments in grey iron foundry practice are traceable to the introduction of steel scrap in cupola mixtures and commonsense methods of mixing and melting; in fact, to one like the author, who has been on the firing line for approximately half a century, it appears as if there has been 100 years' advancement within the past quarter century.

False Claims.—Many text-books, whether by technical or practical men, have maintained that steel reduces carbon. Chemists and metallurgists and practical foundrymen have at times agreed

that (1) steel causes hard spots, (2) will not mix with iron, (3) is not a good thing to use, (4) requires a higher melting temperature, and that (5) manganese is a hardener. The use of steel in cupola mixtures was questioned on all sides, but we learned that carbon will be absorbed from fuel by the steel up to the saturation point, and that manganese above a certain point aids in increasing the saturation point of iron for carbon.

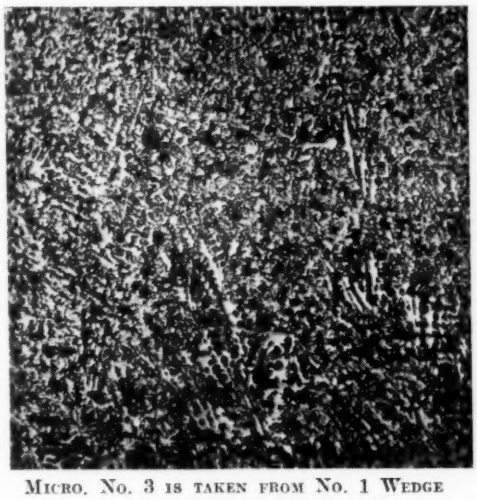
The author has had hundreds of analyses made of both grey iron and semi-steel to learn whether there is less total carbon in semi-steel compared with grey iron, but there is not sufficient evidence to substantiate the claim that steel will reduce carbon.

Carbon Acts as a Medium.

As carbon acts as a medium through which the other elements work, we do not try to remove it from iron, but learn to regulate it by studying the effects produced by silicon, sulphur, phosphorus and manganese. Study the effect of high and low blast on the carbons, and use this knowledge to advantage when calculating mixtures for different castings that require softness, strength, fluidity or chill.

In melting iron in the cupola, carbon will be absorbed from the fuel when a mild blast is used, and the amount absorbed will depend on the amount of carbon in fuel, the power of material to absorb carbon, and the temperature at which iron is melted.

This point alone should enable the student to realise the importance of becoming thoroughly



MICRO. No. 3 IS TAKEN FROM No. 1 WEDGE IN AN INTERMEDIATE POSITION.

alive to cupola operation. When poor coke and high blast are used carbon is lost, and as the total carbon is lowered combined carbon increases in proportion to this loss.

When melting steel for cupola mixtures, high-carbon coke is used for fuel. Coke, of course, can also be used in crucible melting, but in this practice the metal does not come in contact with fuel, therefore does not absorb carbon from it. On the other hand, steel melted in the cupola comes in intimate contact with the fuel, and owing to the very low percentage of the different elements in the steel, it has a strong affinity for them, particularly carbon.

When steel is heated to redness it begins to absorb carbon from the coke, and will continue until they both become incandescent, when the carbon may be 5 per cent.; consequently, it automatically increases the temperature of the melting zone above that of the highest temperature necessary to melt grey iron, and blends with the balance of the mixture.

While it is claimed that the carbons are the predominating elements in iron castings, it is impossible to produce chill castings with high silicon, say, 2.75 per cent.; in fact, the skilful metallurgist insists that silicon be 2.00 per cent. or less to produce a very thin chill, known as a "skin" chill on light castings.

The results of thousands of tests, both physical and chemical, lead one to believe that silicon is the controlling element, although sulphur, phosphorus and manganese play their parts along with the length of time the casting is allowed to cool in mould—all of which have a decided influence on the ultimate proportions of either graphite or combined carbon.

Keep and others claimed that the carbon in liquid cast iron is all in the combined form, but this, as well as the claim that steel scrap, when added to cupola metal, will reduce carbon, did not appeal to the author.

Condition of Carbon in Liquid Cast Iron.

Keep claimed that graphitic carbon is only precipitated from the combined carbon by slow cooling, but the author has poured castings 1-16 to $\frac{1}{8}$ in. thick of 2.75 per cent. silicon iron, when the metal sets or freezes almost instantly. If carbon in liquid iron is all combined, one could hardly expect a precipitation of the graphitic carbon instantaneously, but analyses proved that the carbon was practically all in the graphitic form, consequently the castings were soft.

On the other hand, take a 1.75 per cent. or less silicon metal—pour it into castings 1-16 to $\frac{1}{8}$ in., and the castings are hard with 0.50 or more per cent. combined carbon. It might be reasoned that the higher silicon iron may not have set as quickly as the lower silicon iron, but it is a well-established fact that the lower silicon iron will produce hard castings of thin sections, while the

MICRO. No. 4 SHOWS THAT THE GRAPHITE FLAKES ARE SMALLER IN 10 PER CENT. SEMI-STEEL. IT IS TAKEN FROM THE THICK END OF No. 2 WEDGE.

same sections poured of higher silicon will produce soft castings.

There is no graphitic carbon in steel or white iron because there is very little silicon, so no doubt Keep referred to steel or white iron—not grey iron—when he made the remark that the carbon was all in the combined form.

Semi-steel is the connecting link between iron and steel—combining the fine-wearing qualities of iron with a tensile strength of 19 to 23 tons when using 30 to 50 per cent. steel scrap in medium and heavy sections, and we justly claim it is one of the most valuable products of the grey iron foundry.

Merits of Semi-Steel.

Next to monkeys, man is the greatest imitator, so he watches other men charge steel scrap in the cupola, returns to his shop and does likewise, but not knowing the laws governing the operation he makes a mess of it. If the castings are passable, perhaps soon he is claiming to make semi-steel using half steel scrap.

Now this half-steel claim recalls the story of the man who made a fortune through his famous rabbit pies. A competitor started, but his pies were not so good although he sold large quantities.

One day a friend asked him what he was using,

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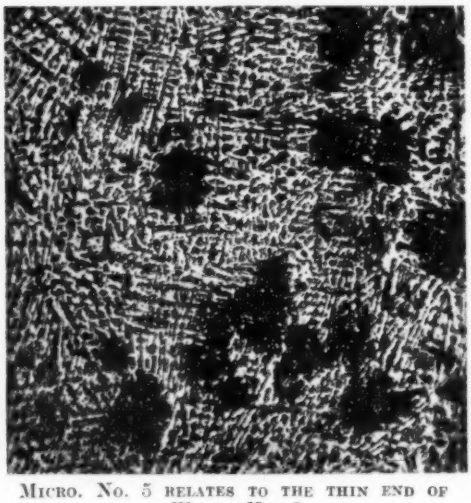
and he said "horse meat and rabbits." "Why," his friend says, "rabbits are very scarce, how do you manage it?" "Oh! I use a 50-50 mixture." "What?" his friend says, "half horse meat and half rabbit?" "Oh no, one rabbit mixed with one horse." And that about hits many foundrymen who claim to use large percentages of steel.

It is only those who recognise the laws of good melting, the merits and advantages of semi-steel, and place themselves in harmony with them, who share the commercial benefits of strong, clean, homogeneous castings and minimum losses—the delight of every true foundryman and engineer.

When properly made, semi-steel exceeds in both temperature and fluidity any other mixture melted in the cupola. The oxidation of the steel when melting scientifically is scarcely perceptible, and when steel is heated in the presence of coke it begins to absorb carbon from the coke, faintly at low temperature, but as the temperature is increased and the steel and coke become incandescent, the steel absorbs large percentages of carbon and no longer is the steel of commerce, but a highly carbonised metal, and will melt before the pig iron in the same charge.

The use of steel in cupola mixtures was questioned on every side—but all such theories were exploded when it was proved that carbon would be absorbed by the steel up to the saturation point, and that manganese above a certain point assisted in increasing the saturation point of iron for carbon, as steel fuses perfectly and it has a strong affinity for carbon, silicon, sulphur, phosphorus, and manganese—proving to the metallurgical world that steel improves the product and that a new principle was discovered and applied with astonishing results.



Micro. No. 5 relates to the thin end of Wedge No. 2.

Micro. No. 6 is taken from Wedge No. 2 in an intermediate position.

Semi-steel is made in the same cupola—in the early or the last part of the same heat with ordinary grey-iron mixtures—no extra coke, special appliances, fluxes, or new equipment are necessary.

Mixtures may contain 30 to 40 per cent. steel on the bed charge—then follow with 20 to 25 per cent. steel—or begin with a small percentage of steel and finish with a large percentage. Flexibility of operation is only one of the many advantages of semi-steel.

Development of Semi-Steel.

There is no subject so interesting to the foundry world to-day as semi-steel, and while a great many are trying to improve their product, they cannot believe that scientific principles govern the ultimate result—even before the materials are charged into the cupola.

The object of this article is to give some plain truths about semi-steel. Many of the statements deal with historical facts dating back fifty years, while many points set forth may be disputed.

For fifty years or more foundrymen have added steel to iron in the ladle, while comparatively few melted slight amounts of steel in the cupola.

A patent was granted in England more than fifty years ago on a cupola mixture which contained only 10 per cent. wrought scrap. Major McDowell was quite successful in using steel scrap in castings of heavy section, but up to 1902 or 1903 the author could find no record of any man having used large percentages of steel in castings of light section.

The author perfected his formula of using large percentages of steel in light sections, and thus developed what he believes is a new metal in 1903—and instead of giving it a fancy name, called it "semi-steel."

The author does not claim to be the first man who used steel in cupola mixtures, but no previous record has been found relating to the successful use of large percentages of steel scrap in castings of light section, and he has taught his process to foundrymen in various parts of the world since 1903.

Nomenclature.

The name "semi-steel" has been abused for years, and will continue to be abused as long as men are satisfied with a mere superficial knowledge. A misapplied and misapprehended term is sufficient to give rise to fierce and interminable disputes; the term "misnomer" has often turned the tide of popular opinion; and while various authors have tried to place semi-steel on the list of misnomers, still the very fact that semi-steel was specified for shells by the Allied governments has placed it as a standard for foundrymen everywhere.

Many claim there is no such thing as semi-steel—that the steel loses its identity and is only grey iron. They forget that pig iron is used to make steel, and while the iron loses its identity they call the resultant metal "steel."

Foundrymen and engineers have also been advised "cast iron is cheap, and heterogeneous, therefore use heavier sections." This dictum has many followers, who are led to believe *one* standard mixture should be used for the entire heat, whether castings are light, medium, or heavy.

Microphotographs of Wedges showing Fallacy of Casting Different Sections from one Grade of Metal.

An experiment which the author believes will prove of great interest to foundrymen is what is called "the wedge test." A pattern is made 16 in. long 2 in. square on one end, tapered to a feather edge 2 in. wide similar to a wedge. A few are moulded and cast from several different mixtures, which correspond to the metal poured in the various castings. The wedges are broken at sections which correspond to different sections of castings and the fracture noted. It will prove that it is a serious mistake to pour castings of different sections of one mixture.

If it is learnt that the metal of ½- 1-, or 1½-in. thickness produces a satisfactory structure for certain castings that require density to resist air, water, or other pressure, it is well to have analyses made of the casting and duplicate mixtures for future work of that character.

To prove the importance of suitable mixtures for various sections, the author cast three wedge test-bars 16 in. long, 2 in. sq. at large end, tapered to a thickness of 3/16 in. Table I. gives the analyses of mixtures, and it will be noted that one is a straight grey-iron mixture and the other two semi-steel, containing 10 and 25 per cent. steel respectively.

TABLE I.—*Analyses of Test Wedges.*

Wedge No.	Material.	Si.	Si	P.	Mn.
1	Grey iron	2.50	0.116	0.70	0.50
2	10 per cent. semi-steel ..	2.25	0.116	0.53	0.53
3	25 per cent. semi-steel ..	3.00	0.085	0.40	1.05

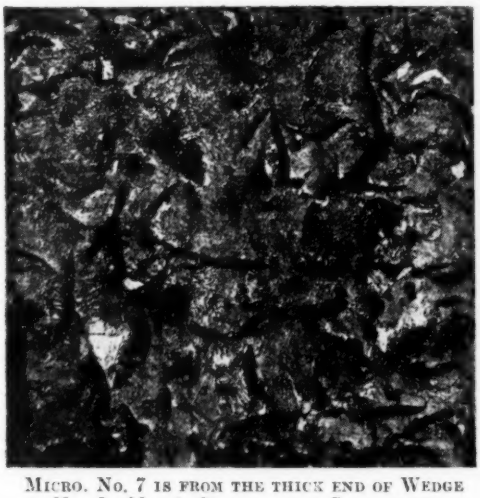
These wedges were examined under a high-powered microscope and microphotographs made of each at the largest end, 2 in. sq., and the thinnest section, approximately 3/16 in.

Micrograph No. 1 was taken from the 2-in. sq. end of cast-iron bar.

The massive black flakes are graphite; the black hair-lines or network are boundaries of white ferrite (pure iron) grains which form the main body or matrix. Here and there are islands of phosphide eutectic, which somewhat resemble a herring-bone structure.

Micrograph No. 2 was made from the same bar as No. 1 at the extreme end where the metal is as cast approximately 3/16 in. The magnification of No. 2 is the same as No. 1, but can one imagine it being of the same chemical analysis?

The light constituent is cementite with dark patches of pearlite. The metal was very hard and brittle; in fact, it was so hard that on the very thinnest edge it was partly chilled.



MICRO. No. 7 IS FROM THE THICK END OF WEDGE No. 3—*id est*, 25 PER CENT. SEMI-STEEL.

Micrograph No. 3 was made from the same bar as No. 2 at the section where the white chilled part appeared to be mingling with the grey.

Micrograph No. 4 was taken from the 2-in. sq. end of the semi-steel, 10 per cent. steel, wedge. While the silicon and phosphorus are somewhat lower than in the grey-iron wedge, the black graphite carbon flakes are not so large and are surrounded by white ferrite, the latter bounded by a dark grey main body or matrix of pearlite. Here and there are small segregations of what appears to be manganese sulphide.

No. 5 is a thin section of the same bar as No. 4—the extreme light end of wedge.

The light constituent is cementite, combined carbon, Fe_3C. The dark constituent is pearlite.

No. 6 is of the same metal as Nos. 4 and 5, but at a point where metal was chilled and the white blends into the grey.

Light constituent is cementite; dark constituent is pearlite.

No. 7 is taken from the heavy end of semi-steel, 25 per cent. steel, wedge. Compare this with No. 1 and note the difference in size of black graphite carbon flakes. The light patches at boundaries of flakes are cementite not entirely broken up. The main body of dark grey is matrix of pearlite.

It must be understood that the author does not advise semi-steel of this analysis for castings 2 in. thick, but in carrying out the main idea of showing structure of metal at different sections, it was considered best to include semi-steel of 25 per cent. steel.

Microphotograph No. 8 was made from the same bar as No. 7 at the extreme furthest end, and metal is of the same analysis.

The light constituent is cementite; dark constituent is pearlite.

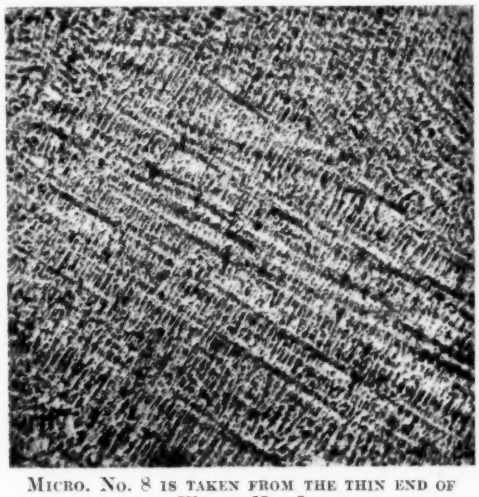
The semi-steel bar from which Nos. 7 and 8 were made is being used for small pistons which are about $\frac{3}{8}$-in. thick when cast and 3/32-in. when machined.

Medium Phosphorus.

While it is well to aim for the very lowest phosphorus in certain mixtures, yet there are foundrymen who cannot follow this suggestion, owing to the lack of materials low in that element, and in that event it should be remembered that, due to the small amount of phosphorus in steel—0.02 to 0.06 per cent.—the more steel used the less phosphorus in the casting.

The founder should aim to use every pound of steel scrap in his mixtures that the section to be poured will carry, especially for castings which must stand hydraulic or other tests.

Assume the mixture required is 50 per cent. pig and 50 per cent. scrap, and the estimated analysis of phosphorus is 1.00 per cent. For every 5 per cent. steel added, take out 5 per cent. pig or return scrap, and this will reduce phosphorus 0.05 per cent., leaving 0.95 per cent. This is set out in Table II.:—



MICRO. No. 8 IS TAKEN FROM THE THIN END OF WEDGE No. 3.

Per cent. steel in mixture.	Per cent. approximate phosphorus in mixture.
10	0.90
15	0.85
20	0.80
25	0.75
30	0.70
35	0.65
40	0.60
45	0.55
50	0.50

The total carbon in semi-steel is higher, and the silicon, sulphur, and phosphorus lower, that is, with the same melting condition, than if the same percentage of the best charcoal or cold-blast pig had been used instead of steel and with different melting conditions.

Steel breaks up the graphitic carbon flakes into granular form, because as the steel absorbs up to 5 per cent. carbon, a higher temperature is produced in the melting zone, and with the extremely high temperature and the metal being purer than grey iron, as it contains less silicon and phosphorus and more manganese, it is freed

from impurities or gases, which insures a close-grained metal leaving no interstices for large carbon flakes.

It is not the carbons alone that make semi-steel better and stronger than grey iron, but the lower silicon and phosphorus that may be used, section for section, therefore many engineers and machinists prefer semi-steel.

Heretofore, if grey-iron castings of ¼- to ⅜-in. section were to be cast, the founder would insist on high-phosphorus iron, but there are thousands of tons of semi-steel made every day for light castings, with 3/16- to ⅜-in. sections, with only 0.20 to 0.40 per cent. phosphorus, and practical foundrymen are frank in saying it is the hottest metal ever seen.

Of course, the high manganese partly offsets the lower silicon and phosphorus, and with a fair percentage of combined carbon, one would expect the metal to be duller in the ladle and harder in the castings.

Steel in its descent in cupola is absorbing carbon from coke, and immediately before reaching melting zone it contains so much carbon (up to 5 per cent.) that it is not steel of commerce but a high-carbon metal that mechanically increases its temperature even above that of the melting zone, which decreases its melting point. We claim most emphatically that when good melting conditions exist steel melts first.

Scientific Melting.

When steel is used in cupola mixtures the entire charging and melting conditions must be changed, especially the manner of lighting cupola and preparing it for charging.

Steel mixtures must be handled differently than iron, both before and after melting. The cupola should be hot, and care is required in charging; in fact, the author's slogan for years was: "Semi-steel must be mixed with brains," because the proper tuyere areas and blast pressures have much to do with the success or failure of it.

It has been stated, and the author believes it is a fact, that casting temperature is the secret of good semi-steel, for without the proper melting and pouring temperatures mixtures are not worth the paper they are written on.

Melting conditions in the steel foundry are approached at an entirely different angle from that of the iron foundry. In the steel foundry the melter in charge usually has many years' practical experience as a third and second hand, and must have a knowledge of furnace construction before given the opportunity to melt steel. But what a difference in the iron foundry!

The steel melter is told what percentage of elements is desired in his steel, and he calculates his charge accordingly. Later, as the heat progresses, he is guided by the actions and reactions taking place in furnace, and then decides what percentage of the deoxidisers (silicon, manganese, or other alloys) is necessary to produce steel within the specifications, but he never attempts to melt steel in a cold furnace.

What a difference the author found when he first began using steel in the iron foundry! Like the majority of foundrymen of those days, he thought he knew all about a cupola, although his foreman claimed to know a great deal more, but between them scant attention was given to the cupola operation. Why?

The cupola was there. It melted iron every heat and had done so for many years. Therefore the author believed the men in charge must understand the process, or, if they did not, the foreman would tell them. But did they? They knew how to melt iron, but the science of melting and the knowledge of cupola details was, and is, sadly lacking in many shops, even to-day.

High blast oxidises a large amount of manganese, silicon, and carbon. By lowering the total amount of carbon a higher percentage of combined carbon is obtained which increases the percentage of oxygen, nitrogen, and oxides—all of which have caused many to condemn semi-steel.

To make real semi-steel, one must be familiar with the fundamentals of scientific melting and the use of steel scrap in cupola mixtures.

High carbon is more essential than high silicon in thin sections for all metal tested to air or water pressure, hence the silicon may be carried much lower than is possible in like sections of grey-iron castings.

But how easy it is to make this assertion look absurd and untrue! The majority of foundrymen have never paid much attention to melting steel scrap in the cupola, and when doing so generally follow someone else's advice, who probably does not know any more about it than they.

They charge the steel in the cupola without a thought concerning its melting, that is, they do not pay attention to whether high or low blast is used. If high blast is used the resultant metal is condemned. It has been proved that while steel could be melted in any cupola, still the metal was not to be depended on, unless good melting conditions existed.

Annealed Semi-Steel.

Some years ago a concern using both steel and malleable castings desired to produce a more satisfactory metal for their product. This company manufactured a line of tools for the hardware and automobile trade. An investigation proved that neither the best malleable nor steel castings gave them the desired results, and our study of the treatment given both malleable iron and steel castings led the author to believe a more suitable metal could be made of annealed semi-steel.

Annealed semi-steel is preferable to either cupola or standard malleable iron for certain castings, as different percentages of steel may be used, depending on section and strength required. It may be hardened and tempered, and the tensile strength is considerably greater than the best malleable iron.

It is the author's belief that annealed semi-steel will supersede cupola malleable for castings more than ¼-in. thick, and even now several railroads are investigating its adaptability for castings over ½-in. section, as the tensile strength will run from 25 to 30 tons.

The cost of producing annealed semi-steel in comparison with malleable iron will depend on the tonnage melted per day, but we believe that, ton for ton, annealed semi-steel would cost less than the best malleable iron.

Annealed semi-steel is white when cast. It is annealed from three to seven days, depending on the sections, and recent experiments of heat treatments lead to the belief that quite a reduction of time will be experienced during the annealing period.

Foundrymen who lack sufficient confidence to make semi-steel instead of straight grey-iron mixtures will hardly be expected to believe that some of the castings made are cast of annealed semi-steel. This metal is made in the cupola, and is very good for wearing purposes, but, of course, will not stand shocks like alloy steels. Annealed semi-steel is very homogeneous, will twist or bend, may be hardened, will stand very high polish, and wears extremely well.

The Spearing Boiler Company, Limited, have been successful in securing the contract for two water-tube boilers, each of a normal evaporation of 52,650 lbs. per boiler, together with Ferguson superheaters, chain-grate mechanical stokers, and forced and induced-draught plant, for the Charing Cross, West End, & City Electricity Supply Company, Limited.

British Empire Steel Corporation.—In connection with the additions to be made to the plant of the British Empire Steel Corporation, Sydney, N.S., to cost $19,000,000, it is stated that the company's engineers are now preparing plans for new open hearths and a blooming mill which will cost about $10,000,000. One blast furnace is to be rebuilt and another extensively repaired, while a number of other additions and improvements will also be made to the plant. It is reported that the money to pay for these improvements is to come from a large loan to be made to the British Empire Steel Corporation by two large American financial houses, the negotiations for the loan being nearly completed. The company's business has been improving for the past three months, and everything points to continued improvement. The Company's pay-roll now amounts to $10,000 per day, this being the first time since November, 1920, that the pay-roll has reached this amount.

An Apprenticeship Course in Foundry Practice.—IV.

By Ben Shaw and James Edgar.

GREEN SAND, DRY SAND, AND LOAM MOULDING.

Moulding may be divided into three distinct classes—green sand, dry sand, and loam moulding. Each class has its own particular characteristics, which depend, to a certain extent, upon the condition of the sand when used, and also upon the time necessary for its preparation to receive the molten metal. Any one of these different classes, or two in combination, are employed in the formation of moulds necessary for the wide variety of castings produced.

The moulder generally specialises in one of these particular classes of moulding, but an apprentice should have facilities for actual experience in each branch in order to assist in determining that for which he is best suited. Unfortunately, all foundries have not the facilities, and in many where they are available the apprentices are not given the opportunity to familiarise themselves by actual practice with any form of moulding apart from that which they commence at the bench or on the floor. No moulder is capable of undertaking the duties of a foreman, particularly in a general foundry, unless he is quite familiar with the operations involved in all the branches of moulding, and while actual practice is not absolutely essential to this end, it is, nevertheless, of the utmost value.

Some foundries make a speciality of green-sand moulding to the exclusion of other classes, some do not make any moulds in green sand, all the work, apart from tackle used in the making of a mould, being done in dry sand, or dry sand and loam, while in others, known as general or jobbing foundries, the work embraces all the different classes of moulding. It is imperative for an apprentice who wishes to become an efficient moulder to get a knowledge of the principles and methods of all the processes. In all foundries where only the green-sand process is employed, an apprentice may be handicapped, but it is still possible for him to take an intelligent interest in loam work, which may open the way to an opportunity for practical experience later on, and enable him in after years to take charge of a foundry where loam and dry sand, as well as green sand, are used.

Green-Sand Moulding.

In a lecture delivered last year by Dr. Alexander Scott, M.A., the following statement was made:—"When one came to deal with the fine grained materials which were present in sand, and which, for convenience, one would call bonding material, it would be found that the grains were not clean, but were surrounded by a very thin pellicle of some other material. In some cases this was clay, sometimes it was quartz, sometimes limonite, sometimes glauconite, and sometimes ferric oxide. In the Aylesbury sand it was a peculiar green silicate of iron and potassium, hence the name "green sand." This is a technical explanation of the term green sand, but for practical purposes it is sufficient to regard the expression green sand as applied to a form of moulding for a similar reason to that which is implied when green timber is spoken of. It means that the sand contains its natural moisture, or has sufficient water added to it to render it workable, and moulds prepared from it receive the molten metal while it is still in a damp condition. It is a weak sand, low in clayey matter or bond, and it is not capable of retaining the form given to it, when the moisture has evaporated, hence while it depends upon the moisture for giving the amount of plasticity, without which the desired impression could not be made, it is equally as essential at the time of casting to give the sand strength to resist the rush and pressure of the metal. A sand-mixture, strong in bond, cannot be used satisfactorily for green-sand moulding, the additional clayey matter and the moisture reducing the pore space between the sand grains, which prevents the metal lying against the moulds so constituted, causing them to "blow," the steam and gases generated at the time of casting not being able to escape through the sand quickly enough.

This class of moulding is employed in a more or less degree, for all metals and alloys common to the foundry, although it is necessary to grade the fineness and composition of the sand according to the metal for which it is to be used. As a rule green-sand moulds consist of two kinds of sand, the ordinary floor, or backing sand, which has been in use and lost to a certain extent its cohesive power, and facing sand, which is really that with which the metal comes into contact. This facing sand is specially prepared according to the character of the work to be done, and the metal to be cast against it. While all sand-mixtures used in green-sand moulding are weak compared with those used in other classes of moulding, there are different degrees of strength, and generally a stronger-bonded sand can be used for castings having comparatively heavy sections than is possible with light work. The facing sand for moulds to receive cast iron contains a percentage of coal-dust, and this mixture is frequently referred to as a strong or weak facing sand, according to the amount of coal-dust it contains without reference to its bonding qualities. A weak facing sand implies that the percentage of coal-dust is low, a condition which is desirable for castings of light section. Other ingredients may be introduced instead of coal-dust, such as finely ground coke and charcoal or blacking, but coal-dust is comparatively cheap and quite as effective for this purpose.

Coal-Dust.

Coal-dust is really added to protect the face of the mould, thus ensuring a better skin on the casting, and although it is frequently referred to as a means of increasing the porosity of the sand under the heat of the metal, its value in producing a better skin on the casting is a more important consideration. The heat of the metal generates a gas from the coal-dust which forms a thin protective cloud about the face of the mould, preventing the direct contact of the metal with the sand surface. This is responsible for the comparatively clean skin produced on the castings. The difference in quality of surface produced on iron castings can easily be seen by using facings with and without coal-dust. When it is not used the metal has direct contact with the sand and at the high temperature it acts upon the impurities in the mixture, and fluxes, caused by small particles of slag, adhere to the metal surface. The surface of the castings is therefore roughened, and not comparable with that produced when the facing contains coal-dust. Partly for reasons of economy, and the fact that too much coal-dust would be injurious, the percentage is graded to suit the thickness of metal, varying from one of coal-dust to seventeen of sand for light work to one in eight for castings of heavy sections. Only that amount is required which will maintain the film of gas until the casting has solidified. Coal-dust is not used as an admixture for green sand moulds which are to receive molten steel, because the gas formed would not withstand the higher temperature and would, therefore, be of no value as a protection for the sand. The facing mixtures must be particularly free from impurities for this class of work, and flour silica, together with graphite, may be dusted over the moulds and sleeked where possible, as an additional protection against impurities.

The facing sands used for brasses and bronzes frequently contain coal-dust, particularly when the moulds are to be skin dried, but for ordinary green-sand moulds the admixture can be neglected in favour of a dusting of pease-meal, or a mixture of pease-meal and French chalk.

While reference has been made to skin-dried moulds, it must be distinctly understood that those are different from dry-sand moulds. The purpose of skin drying green-sand moulds is to obtain a skin on the casting which more nearly approxi-

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mates to that produced in dry-sand moulds without the loss of time involved in complete drying.

The actual mixtures used for facings cannot be given satisfactorily in this article, as they depend largely upon the character of the new sand and the work for which they are to be used. The proportion of new sand to old sand is smaller for light work than for heavy work, but the amount depends upon the clayey content of the new sand. It is important that the moisture content should be low with all green-sand facings. An excess of moisture would hinder the metal from lying quietly against the mould and cause it to blow. The increased quantity of steam generated, and the decreased pore space, due to the excess of moisture, result in the fluid metal offering the least resistance to the escape of the steam. This is a frequent cause of water castings.

The quantity of moisture desirable is frequently considered as a percentage of the whole, thus from 5 to 7 per cent. of moisture is generally accepted as a convenient quantity. This method of computation is quite satisfactory when the facing is prepared in a mixer and both old and new sand are added dry; then the requisite amount of water can be added. This is a practice which is often resorted to for green-sand work in steel foundries, but when the sands to be mixed contain moisture the percentage method is not a very convenient one. Experience is of great assistance in determining whether the facing sand contains about the right quantity of moisture. The simple method of squeezing a quantity of sand with the hand is frequently used to determine its condition with regard to moisture and also plasticity. When the hand is opened the sand should maintain the shape given to it, and leave the hand quite clean, if sand adheres to the fingers it is too damp, and if the shape breaks up into a number of pieces, is loose or friable, then it is not damp enough. Facing-sands are best prepared in a mixer, in order that the composition may be regular, but in many jobbing foundries, when almost every job requires a special mixture, the moulder is responsible for his own facing sand, and it is then mixed by hand with the necessary amount of coal-dust added to suit the particular work.

The most important advantage possessed by moulding in green sand is its relative cheapness combined with rapidity of production. Metal can be cast directly the moulds are completed, assembled and clamped, and there is the further advantage that tackle and equipment can be used more than once in the same day.

Dry-Sand Moulding.

In this class of moulding the sand is used in a somewhat similar condition to that suitable for green-sand moulds, but it is dried preparatory to receiving the molten metal. It is a strong sand containing more clayey matter than green sand in order that moulds prepared from it will have stability when dried. The increase in the proportion of clay closes the texture of the sand and reduces its permeability, and for this reason all moisture must be removed not only to reduce the amount of gas generated, but to open the pores of the sand. A damp sand is less permeable than a dry sand, other things being equal, because much of the pore space is occupied by the moisture. The difference in the strength of the sands used is a most important distinction between green-sand and dry-sand moulding. The former is open in texture and is weak in bond, and the moisture is essential to give it body or strength, otherwise it would crumble and collapse before the molten metal, whereas strong sands are close in texture and must have all moisture driven from them so that gases generated at the time of casting will escape more readily without injuring the surface of the metal. Backing sand, which is floor sand and facing sand combined, is also used in the making of moulds to be dried, and it must be distinctly understood that the floor sand is distinct from that which is used for green-sand moulding, being limited to that sand which has previously been used for dry-sand moulds. Coal-dust is not added to the facing mixture, but a protective coating is applied to the surface of the mould after it has been dried, which answers the same purpose, and indeed, gives a better face on the casting.

It is of little value giving representative mixtures for facing sands suitable for dry-sand moulds. The character of the work to be done, the kind of metal to be cast, and the composition of the moulding sand at hand, are the factors which determine the mixture. Practical experience is essential to maintain regular quality of facing sand from day to day for similar classes of work. Those for cast iron frequently contain a considerable quantity of loam which has been previously used, and a quantity of new sand in the mixture can then be reduced. When loam is not available, old sand is mixed with new in varying proportions according to its strength.

Some sands are very weak, while others are very strong. With the former only available as a new sand it is advisable to maintain a supply of clay to maintain the requisite strength. It is better to dry and pulverise the clay before introducing it to the mixture, or as an alternative, the requisite amount may be mixed with the water which is used to temper the mixture of sand. When the mixture is considered to be too strong, sharp sand or sea sand may be introduced to lower its clayey percentage and open the texture; in some cases coal-dust is used for the same purpose. These mixtures are preferably milled in order to toughen as well as thoroughly mix them. Considerable care is necessary in the milling, as it is possible to render the sand lifeless by too much milling. About ten minutes milling for a coarse facing such as would be required for a large job, and about twenty minutes for a fine facing sand is about the average amount of milling suitable for extreme grades. This is, of course, only a rough guide, as there are different forms of sand mills, having rollers of different weight, which revolve at varying speeds, but it is sufficient to draw attention to the fact that facing sand can be overmilled. Prepared facings should be passed through a disintegrator after milling in order to aerate it, though many foundries are content with passing it through a mechanical riddle before leaving the mill.

Facing mixtures used for cast iron suffice as a rule for moulds to receive brass or bronze. This does not mean that the same mixture should be used for both iron and brass, but mixtures having a similar degree of refractoriness, permeability and strength. More refractory facing sands are necessary for moulds to receive steel involving the use of a purer sand. For light and medium sized work, sand which has previously been used is milled with new sand according to the strength required. Pulverised china clay is frequently used to increase strength when desirable, because of its freedom from impurities. Many prefer to have a washed sand, that is, sand from which the clayey matter has been removed, and to this is added a quantity of new sand and the requisite amount of clay. It is important to remove the fine earthy matter into which the clay is converted under the heat of the metal from the used sand. For heavier work "compo" which has been previously used, together with a certain amount of new sand is milled to provide the facings.

Dry-sand moulds are adopted in preference to green sand, when the additional cost of preparation and drying is compensated by a reduction of bad castings, such as might be expected if green sand is used. Greater risk is attached to the making of sound castings in green sand, and the degree of risk is increased in proportion to the size and intricacy of the casting to be made. Though a better defined shape is obtained in green sand, the surface produced in the castings is inferior to that on dry sand work.

Loam Moulding.

This class of moulding differs considerably from those previously described. Though the mould surface, when completed, is similar to that of a dry-sand mould, the condition of the sand or loam when used, the method of application, and the construction of moulds are very different. The loam has a consistency resembling that of plaster, it being used stiff or thinned with water as circumstances warrant. Bricks are involved in the building of loam moulds, and cast-iron plates introduced to support them and to give facilities for lifting. The moulds, when completed, are dry

and the surface with which the metal has to come into contact are blackwashed in a similar manner to dry-sand moulds. The mixtures of sand used are not unlike those used for dry sand work, but as a rule they are stronger. While there are many mixtures known by many names common to the foundry or districts in which they are used, they are generally divided into three classes, common or building loam, facing loam, and core loam. The common loam compares with the floor or backing sand in dry sand work, and is used in the same manner as cement, that is between bricks when building a mould, the surface of the mould to receive the metal consisting of facing loam which is finer. Owing to the greater strength of these mixtures, it is necessary to introduce openers in order that the moulds will be sufficiently porous at the time of casting. For this purpose chopped straw, horse-dung and cow hair are commonly used. Many founders reduce the strength with ground coke, or sharp sand may be added until the facing loam has the required strength.

Strong facings crack considerably on drying, and great care has to be exercised in filling to avoid corresponding marks on the castings.

Core Loam.

Core loam is prepared in a similar manner, but special mixtures are required which will be sufficiently loose and friable, after the metal has been cast, to be readily removed from the cooled casting. As a strong loam bakes very hard, and, apart from the resistance offered to the casting during the time of cooling, is most difficult to remove from the casting when cleaning, it should, therefore, be reduced in strength, and for this purpose chopped straw and also sawdust may be added. Sometimes common blacking is also added, and this helps to disintegrate the loam after the metal has been cast.

Moulding in loam is limited to medium and large sized work simply because it has little economical value for small work. Owing to the fact that a pattern can be wholly, or to a very great extent, dispensed with, it is a method much used for the production of cylindrical castings. A sweeping board having a profiled edge similar to the cylindrical shape desired can be used, and those parts which cannot be swept are made of loam, and either introduced into their respective positions during the time of sweeping, or attached after the shape has been struck up. The mould required may be swept to shape, or a loam pattern may be prepared, which, when dried can be used to provide a mould in sand or loam.

Full patterns, that is patterns having a solid exterior, are not suitable for loam work though many are used. The wood absorbs a considerable quantity of moisture from the loam and causes it to swell. This frequently alters the important dimension of the pattern. Another disadvantage of the full pattern is encountered when stripping; it is necessary to stove the mould before the pattern is withdrawn and resinous matter from the wood is absorbed by the loam causing it to stick or weakening the face of the mould, which may cause it to scale when it receives the metal. When patterns are necessary, the wood-work on them should be limited, frame skeleton, or what might be termed skeleton shell patterns, being most suitable.

The choice of loam, dry sand, or green sand, depends largely on the general practice of the foundry, the design of the work, and also, as has been already stated, by its size. Some foundries make a speciality of loam work, while others only use loam for moulds when the pattern work supplied leaves no option.

Of the three classes, loam moulding gives the greatest scope to the moulder. He must possess initiative and ingenuity in deciding upon an economical method of construction suitable to the work in hand, and also in devising suitable tackle. The capacity for reading drawings is of greater value to the loam moulder than either the green or dry-sand moulder, because, as the pattern work is as a rule limited, he must be guided by the drawing. In each class, however, there is ample room for the development of the highest skill, not only in the manipulation of the sand or loam, but in devising the construction of moulds to the best advantage.

New Suggestions for Notched-Bar Tests.

In a recent issue of "Stahl und Eisen," DR. STRIBECK discusses the question of shock tests on notched bars. While not denying their importance in acceptance tests, he advises greater caution in accepting the results of such tests without a more thorough investigation of the principles on which they are based. He bases his opinions on a series of tests which he has carried out and on the tests of other workers. Whereas when judging materials with regard to the specific purpose for which they are intended, it may be sufficient to do so from the point of view of their physical suitability, *i.e.*, their structure, in practice, notched-bar tests must proceed from the basis of the materials as technically prepared in the workshop for specific purposes. This is, of course, in addition to securing uniformity in the shape and size of test-pieces. Taking the case of the tests carried out on boiler-plates, the author points out that the German regulations of 1907 state that the rolled surfaces of the plates form the lateral margins of the notched test-pieces. The width of the cross-section of the bar is therefore equal to the thickness of the plate. The reduction in cross-section due to the notch has always to be 15 mm. (0.6 in.) high. The test bars of plates of different thicknesses have therefore different widths where the height is the same.

Tests by various authorities, however, have shown that, where the test-pieces exceed a certain width, the specific work of impact falls off sharply and exhibits irregularities. By means of a curve the author shows that the specific work of impact decreases with increasing width of test-piece, this decrease not being regular or steady, but giving rise to a gap in the curve which the author calls a "zone of aberration." This zone depends in height, width and position, on the chemical composition of the iron and steel, and on the mechanical and heat treatment to which it is subjected. The result is that the consumer sometimes rejects plates as unsatisfactory in quality, which are really quite good. The practice, therefore, of making the width of the test-piece equal to the thickness of the plate, and the height of the dangerous cross-section invariable, is untenable. In place of this the author suggests (1) that the thickness of the plate should be regarded as the width of the test-piece, the height of the test-piece being fixed at a proper ratio to the former. This, however, would give very small cross-sections for a plate only 5 mm. thick. (2) It would be better to make the notch starting from the roller surface of the plate so as to fix the width of the bar. In the former case the cross-section would have to be defined for various thicknesses of plate, while in the second case both the width and height would have to be so defined.

The use of the round notch only for small test-pieces of 8-10 cm. (say 3 in. to 4 in.) the author regards as likely to impair the efficiency of the notched-bar test. Only by using a sharp, angular notch is the test rendered valuable as an acceptance test for materials having a high notch tenacity. The notched-bar test must not, however, be regarded as satisfactory for all classes of iron and steel. It ought not indeed to be prescribed at all for materials of low notch tenacity.

The dependence of notch tenacity on the rate of impact is another matter requiring careful consideration, the German authorities having considered that in the Charpy test the effect of the velocity of impact is negligible. The author argues against this view, urging the possibility that certain materials may have a "zone of aberration" (as already noted) in the sense that the work of impact within certain limits of velocity may be sometimes high and sometimes low, according to the zone of aberration, which itself depends on the width of the test-piece. In judging of materials from their notch tenacity, their behaviour at very high velocities should also be studied. Only those materials should be included which exhibit a high degree of notch tenacity even at very high "striking velocities." As "rate of impact" is not synonymous with "velocity at impact," the velocity of the tup after breaking through the test-piece should be considered.

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The Development and Manufacture of High-Tenacity Brass and Bronze.*

By O. Smalley, M.Inst.M. (Newcastle-on-Tyne).

(*Continued from page* 80.)

Aluminium Manganese Brasses.

For the purpose of this investigation the ternary alloys A1, A2, A3 and A4 were taken as basis, the Mn. additions replacing the Zn.

Manufacture.—Constant conditions were maintained throughout, and were those adopted in the ternary series. Mn. does not improve the casting qualities, and unless great care is taken, overlaps and surface unevennesses are formed owing to the ready oxidation in the molten state. No difficulties were encountered in forging, rolling, extruding or cold drawing. Owing to the polymorphic nature of the "Alpha-Beta" series, higher temperatures than 750 deg. C. and rapid cooling after working should be avoided, otherwise they will possess the properties of an all "Beta" brass. When hardened or embrittled by such treatment arnealing at 650 to 700 deg. C. is recommended, and cooling to 500 deg. C. during a period of at least one hour.

Effect of Manganese on 1 per cent. Aluminium Brasses.

Alloy AM5, Table VIII., shows the effect of 3.5 per cent. Mn. on alloy A1, retaining the Cu. content constant at 59 per cent. In the cast condition the yield point, maximum stress and hardness are practically unchanged, but the ductility as measured by both static and dynamic stress tests is lowered. Forging reverses this state of affairs, the manganese alloy being superior in both tenacity and ductility, although each offers a good range of mechanical properties.

Fig. 11 illustrates the micro-structure of AM5 in the "cast" condition, and shows Mn. to reduce the size of the crystal grains, to break down the junctions of adjacent grains, and to increase the quantity of the "Alpha" constituent. This latter feature corroborates the author's previous finding that Mn. is a Cu.- rather than a Zn.-replacing element. In view of the observed structural change, the natural corollary is that Mn. is beneficial to the ductility and toughness of Al. brass castings, yet actually, the reverse proved to be the case.

The explanation of this is clear from Fig. 12, which shows films of a brittle Mn.-rich constituent to have formed at the junctions of the adjacent crystal grains. The advantage, therefore, of the refined texture does not appreciate until this undesirable structural weakness has been eliminated. Fig. 13 shows the effect of forging in this direction, and to have conferred to the forging a grain which strengthens against stress applied at right angles to the grain, but weakens it against stress applied parallel with it.

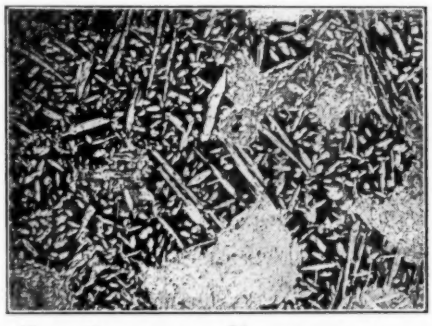

Fig. 11, showing Microstructure of Alloy AM5 "As Cast."

TABLE VIII.—*Showing the effect of* 3.5 *per cent. Mn. on alloy* A1.

Mark.	Composition. Cu.	Zn.	Al.	Mn.	P.	Fe.	Physical Condition.	Y. P. Tons per sq. in.	M. S. Tons per sq. in.	E. Per cent. on 2 in.	R. A. Per cent.
A.1.	59.48	39.55	1.00	Nil	Nil.	Nil.	As cast ..	14.80	32.00	30.00	33.50
							As forged ..	11.10	31.30	41.00	44.60
AM.5.	59.45	35.85	0.98	3.49	0.01	0.22	As cast ..	13.40	31.80	25.00	24.60
							As forged ..	20.70	35.10	36.00	47.20
A.2.	58.35	40.11	1.54	Nil.	Nil.	Nil.	As cast ..	16.40	35.20	17.00	18.50
							As forged ..	11.60	36.40	28.00	34.00
AM.2.	59.45	36.60	1.56	1.97	0.02	0.40	As cast ..	17.00	35.90	22.00	20.00
							As forged ..	17.20	37.00	28.00	30.60

TABLE VIII.—continued.

Mark.	Tensile Fracture.	Alternating impact No.	Fracture.	Brinell hardness No.	Sclero-scope hardness No.	Crysta grains per sq. cm
A.1.	Coarse, stony, accicular. Trace of inter-crystallinity along the 2 in. parallel.	46	Fine, stony	114	21	$a\beta$
	Fine, stony, free from inter-crystallinity	67	Fine, stony, semi-vitreous ..	104	18	$a\beta$
AM.5.	Fine, granular, short. Extension uniform over the 2 in. parallel.	18	Fine, stony, crystalline ..	114	21	$a\beta$
	Stony, granular, cup and cone, silky edges.. ..	75	Fine, stony, silky	134	23	$a\beta$
A.2	Between A.1 and No. 6, in appearance	23	Coarse, crystalline, stony ..	120	21	$a\beta$
	Crystalline	41	Coarse, crystalline, stony ..	138	22	$a\beta$
AM.2.	Highly crystalline, very pale yellow, free from lustre. Trace of inter-crystallinity along 2 in. parallel.	27	Short, fine, crystalline, with a slight lustre.	138	26	143
	.. ..	41	Fine, stony, granular. Trace of inter-crystallinity.	148	33	170

Effect of Manganese on 1½ per cent. Aluminium Brasses

The test results in the "As Cast" and in the "Forged" conditions are included in Table VIII.,

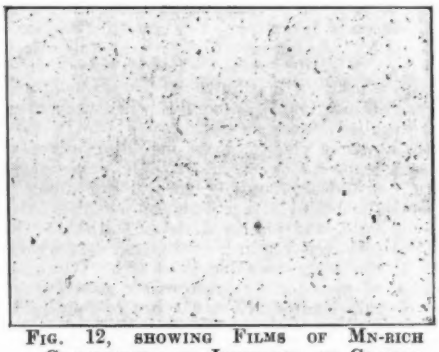

Fig. 12, showing Films of Mn-rich Constituent at Junctions of Crystal Grains.

alloy AM2. The Mn. additions are limited to 2 per cent., no object being served by exceeding

this amount. The tensile and impact tests suggest Mn. to slightly improve the ductility. Apart from this, its influence is apparently negligible in either the cast or forged state.

Micro-structure.—Manganese shifting the position of the "Beta" phase field-boundary to the right, the micro-structure is changed from an all

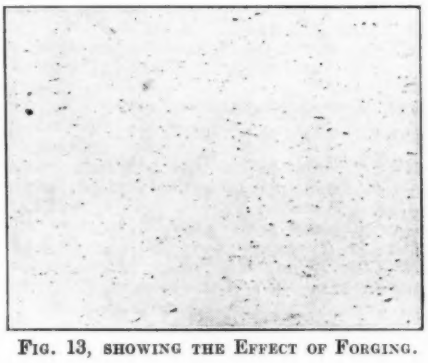

FIG. 13, SHOWING THE EFFECT OF FORGING.

"Beta" brass to an "Alpha-Beta" brass. This does not imply the mechanical properties of alloy A1. or allow AM5—both of which contain 40 to 50 per cent. of the "Alpha" phase—as the predominating micro-constituent determines the final physical properties.

The structural change wrought by the addition of 2 per cent. manganese on alloy A2 is shown in Fig. 14, although this alloy contains 1 per cent. of Fe. in addition to 2 per cent. Mn.

Mn. appears to reduce the shock-resisting properties in the "cast" state, and 2 per cent. Mn. to increase the yield point, maximum stress and hardness without affecting the ductility. Reducing the Cu. content of the latter alloy to 57 per cent. and proportionately increasing the Zn. content (alloy AM3D), apparently lowers the yield point without affecting the tenacity and hardness, but

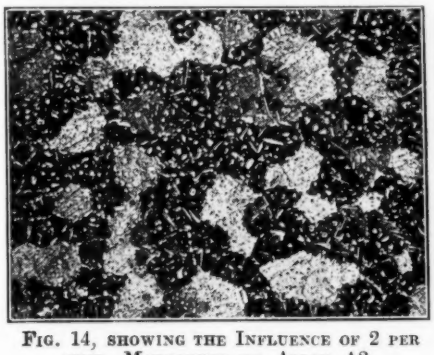

FIG. 14, SHOWING THE INFLUENCE OF 2 PER CENT. MANGANESE ON ALLOY A2.

improves the ductility as measured by both the tensile and impact tests.

Reverting to the 3 per cent. Al.-59 per cent. Cu. basis brass, 4 per cent. Mn. (alloy AM13) raises the yield point maximum stress and hardness, but adversely influences the ductility. The improvement made by forging, demonstrates the value of Mn. in these alloys in the forged, stamped, rolled of extruded conditions.

Micro-structure.—Each alloy was found to pos-

TABLE IX.—*Showing the Effect of Manganese on Aluminium Brass.*

Mark.	Composition. Cu.	Zn.	Al.	Mn.	Pb.	Fe.	Physical condition.	Y. P. Tons per sq. in.	M. S. Tons per sq. in.	E. Per cent. on 2 in.	R. A. per cent.
A.3.	58.26	38.56	2.18	Nil.	Nil.	Nil.	As cast ..	16.00	36.40	16.00	21.50
							As forged ..	13.00	38.90	22.00	30.00
AM.4.	58.15	35.18	2.24	4.10	0.08	0.25	As cast ..	23.90	40.50	14.00	15.00
							As forged ..	24.80	43.40	18.50	21.50
AM.2B	57.23	37.90	2.59	2.08	Nil.	0.20	As cast ..	19.40	41.40	18.00	20.00
							As forged ..	20.50	42.60	24.00	24.50

TABLE IX.—continued.

Mark.	Fracture.	Alternating Impact No.	Fracture.	Brinell hardness No.	Sclerescope hardness No.	Crystal grains per sq. cm.
A.3.	Coarse, crystalline	25	Coarse, crystaline, stony ..	138	22	202β
	Crystaline	39	Coarse, crystaline, stony ..	143	23	149β
	Whitish yellow colour. Coarsely crystalline. Free from lustre. Inter-crystalline along the 2 in. parallel.	15	Whitish grey. Coarsely crystalline.	165	—	192 β
A.M.4.	Whitish yellow colour. Oblique, hackly. Marked crystalline. Free from inter-crystallinity along the 2 in. parallel.	39	Whitish grey. Fine crystalline.	159	—	3.700 β
A.M.2B	Fine, crystalline	20	Stony, strongly crystalline at outer edges.	165	25	387
	Oblique, even, crystalline, high lustre	29	Fine crystalline, stony. Presence of trace of a larger crystalline structure due to incipient overheating.	159	28	467

Effect of Mn. on 2, 2.5 and 3 per cent. Al. Brasses.

By a further addition of 1.0 per cent. Al. to the 1 per cent. Al.-4 per cent. Mn., alloy (AM5), the yield point and maximum stress are appreciably increased, but at the expense of the ductility as in alloy AM4 in Table IX. By raising the Al. to 2.5 per cent., reducing the Mn. to 2.0 per cent. and the Cu. to 57 per cent. (alloy AM 2B, Table IX.), the test results are very similar to those obtained from alloy AM4, excepting that the yield point is lower.

In view of the interesting test results obtained from the 3 per cent.. Al. brass (alloy A4, Table II.) a series of alloys of this type was prepared, and a new standard marked No. 6—Table X. To the first, 1 per cent. Mn. was added, to the second 2 per cent. Mn., to the third 4 per cent. Mn., retaining the Cu. and Al. constant at 59 per cent. and 3 per cent. respectively.

Complete data regarding composition and test results are given in Table X. Here 1.0 per cent. sess in all "Beta" structure. The Mn.-rich constituent formed in alloys AM4, AM2B, AM3C, AM3D and AM13, is responsible for the embrittlement in the "cast" state and a reduction in the size of the crystal grains. A notable structural feature of Mn.-Al. "Beta" brasses is the interpenetration of the adjacent grains, and the evidence of a more mixed orientation. This is particularly well-displayed by the fracture. Generally speaking Cu. Zn. "Beta" brasses and Al. "Beta" brasses present a coarse crystalline fracture with bright crystal facets, whilst Al. Mn. "Beta" brasses invariably exhibit a mixed granular and crystalline fracture, and the crystal facets lack lustre and have a stony appearance.

Aluminium-Manganese-Iron Brasses.

The principal high-tenacity brasses of to-day contain Al., Mn., and Fe. They vary widely in composition, but generally fall within the following limits:—Cu., 57 to 64; Zn., 31 to 40; Al., 0.20 to

4.0; Mn., 1.0 to 4.0; Fe, 0.10 to 2.0; and Sn., nil to 1.0. Although alloys are made which do not come within this range, some of which contain as many as 15 elements.

refining the texture, its value, if any, must be that of a toughener.

Alloy AM6, in Table XI., shows the effect of 1.0 per cent. **Fe.** on alloy AM2—the Fe. meant to

TABLE X.

Mark.	Actual composition. Cu.	Zn.	Al.	Mn.	P.	Fe.	Physical condition.	YP. Tons per sq. in.	MS. Tons per sq. in.	E. Per cent. on 2 in.	RA. Per cent.
6	58.85	38.05	3.10	Nil.	Nil.	Nil.	As cast	20.50	38.60	19.00	21.50
							As forged ..	18.90	43.00	29.00	33.50
AM.12	58.87	37.13	2.94	0.96	Nil.	0.10	As cast ..	20.80	38.70	11.00	11.80
							As forged ..	20.50	40.80	22.00	24.50
AM.3C	59.34	35.34	3.10	2.02	Nil.	0.20	As cast ..	23.70	43.00	15.00	15.00
							As forged ..	23.60	43.40	19.00	24.50
AM.3D	57.07	37.68	3.12	1.81	Nil.	0.32	As cast ..	19.80	43.90	20.00	21.50
							As forged ..	20.70	44.90	33.00	44.60
AM.13	58.32	34.54	3.12	3.92	Nil.	0.10	As cast ..	22.80	45.30	13.00	20.00
							As forged ..	24.50	43.80	22.00	27.60

TABLE X.—continued.

Mark	Tensile Fracture.	Alternating Impact No.	Fracture.	Brinell hardness. No.	Sclero-scope hardness. No.	Crystal grains per sq. cm.
6	Coarse, crystalline, deep reddish colour	30	Coarse crystalline, reddish colour	148	—	152
	Flaky, coarse, crystalline, deep reddish colour ..	49	Fine, crystalline, reddish colour.	159	—	2.555
AM.12	Coarse, crystaline. as No. 6 but not quite so lustrous.	9	As No. 6, but not quite so lustrous.	159	—	—
	Fine, reddish, granular, flaky	29	Fine, reddish, mixed, crystalline and granular.	159	—	—
AM.3C	Coarse, crystalline, stony, with a slight lustre. Trace of inter-crystallinity.	23	Stony. Crystalline at outer edges.	171	27	125
	Between AM.1 "Forged" and AM2B. "Forged" in in appearance, and is free from inter-crystallinity along the 2 in. parallel	39	As AM.2B. "Forged." ..	165	30	62
AM.3D	Coarse, crystalline and much inter-crystallinity ..	23	Fine, crystalline, exhibiting inter-crystallinity.	154	—	760
	Fine, red fracture, free from inter-crystallinity ..	93	Fine, amorphous, indicating "Forging" too cold.	165	—	3200
AM.13	Mixed fracture, mainly earthy, what crystallinity is present is free from lustre.	14	Fine, whitish, earthy, with a tinge of crystallinity.	171	—	—
	Fine, earthy, granular, laminated, rough ..	70	Fine, whitish, earthy, granula r	171	—	—

TABLE XI.—*Showing the effect of* 1 *per cent. Fe. on alloy AM2.*

Mark.	Actual composition. Cu.	Zn.	Al.	Mn.	P.	Fe.	Physical condition.	Y. P. Tons per sq. in.	M. S. Tons per sq. in.	E. Per Cent. on 2 in.	R. A. Per Cent.
AM.2	59.45	36.60	1.56	1.97	0.02	0.40	As cast ..	17.00	35.90	22.00	20.00
							As forged ..	17.20	37.00	28.00	30.60
AM 6	58.74	36.61	1.60	1.83	Nil.	1.22	As cast ..	17.90	36.50	19.00	21.50
							As forged ..	17.80	36.90	34.00	46.00
AM.11	58.76	35.16	1.95	3.43	Nil.	0.20	As cast ..	22.00	39.60	13.00	18.30
							As forged ..	21.00	40.70	17.00	21.50
AM.14	58.11	34.31	1.95	3.98	Nil.	1.65	As cast ..	21.10	42.30	14.00	18.30
							As forged ..	19.90	39.50	28.00	33.50
AM.3C	59.34	35.34	3.10	2.02	Nil.	0.20	As cast ..	23.70	43.00	15.00	15.00
							As forged ..	23.60	43.40	19.00	24.50
AM 3B	59.67	32.73	3.30	2.05	0.27 (Silicon)	2.25	As cast ..	25.00	43.70	13.50	18.30
							As forged ..	24.70	44.00	27.00	33.50

TABLE XI.—continued.

Mark.	Tensile Fracture.	Alternating impact No.	Tensile Fracture.	Brinell hardness No.	Sclere-scope hardness No.	Crystal grains per sq. cm.
AM.2	Highly crystalline, very pale yellow, free from lustre. Trace of inter-crystallinity along 2 in. parallel.	27	Short, fine, crystalline, with a slight lustre.	138	26	143
	.. ..	41	Fine, stony, granular. Trace of inter-crystallinity.	148	33	170
AM.6	Fine, earthy, semi-cup and cone	33	Fine, crystalline	129	21	3,937
	Fine, earthy, semi-cup and cone	46	Fine, crystalline	138	22	4,500
AM.11	Coarsely crystalline. Whitish grey. Free from lustre.	20	Fine, stony, almost free from crystallinity.	159	—	239
	Oblique, shear-like appearance	44	Fine, stony, free from crystallinity.	159	—	187
AM.14	Fine, crystalline, whitish grey, almost earthy ..	17	Short, fine, earthy	165	—	6,365
	Fine, yellow, earthy, granular, silky edges ..	41	Fine, earthy	159	—	14,215
AM 30	Coarse, crystalline, stony, with a slight lustre. Trace of inter-crystallinity.	23	Stony, crystalline at outer edges.	171	27	125
	Between AM.1 forged and AM.2.B forged in appearance, and is free from inter-crystallinity along the 2 in. parallel.	39	As AM.2.B forged	165	30	62
AM.3B	Dull yellow, spongy appearance, shallow semi-cup and cone, silky edges.	17	Fine, crystalline, dull ..	171	31	5,824
	Granular, semi-cup and cone. Trace of silky edges.	43	Fine, crystalline, pale brown, free from lustre.	178	31	11,020

That Fe. cannot be regarded in the light of a hardener or strengthener in this class of alloy has been established by the iron-brass series. Acting as a Cu.- rather than a Zn.-replacing element, and replace 1.0 per cent. **Zn.** In the chill cast condition, the tensile and hardness figures remain unchanged, although the toughness is somewhat improved. The change in this direction is by no

means proportional to the corresponding reduction in the size of the grain, the full advantage of which does not appear to materialise until the cast structure has been broken down by mechanical work.

Fig. 14 shows the micro-structure of alloy AM6 and illustrates the structural changes wrought in alloy A2 by the substitution of 3.0 per cent. of Zn. by 2.0 per cent. Mn. and 1 per cent. Fe.

Alloy AM14 serves to demonstrate the effect of 1½ per cent. Fe. on alloy AM11. Here, again, the grain refining effect of Fe. does not improve the mechanical properties until after forging. Alloy AM3B exhibits identical features and special comment is not necessary, the test results and details of the fractures being self-explanatory.

Before concluding this section, attention should be drawn to the yield point figures given in this Paper, which appear in some instances to be both erratic and contradictory. In considering the elastic properties of brass, however, it must be remembered that there is no uniform relation between the proportional limit and the yield point, and that from the ordinary extensometer diagram it is difficult to locate where the elastic state ends and the plastic state begins, or even make a satisfactory comparison of the form of the curves of one alloy with that of another. The yield point figures given indicate the stress to produce a permanent set of 0.01 in. on a 2-in. gauge length, and nothing more. They are included in this Paper because of their common insertion by the engineer in his specification, although some form of dynamic stress test would better serve his purpose.

Heat Treatment.

From the comments made on the microstructure of these brasses, it is evident that high strength brasses may be divided into three categories, "alpha," "alpha beta," and "beta," according to the predominating micro-constituent.

"Alpha" and "beta" brasses being unaffected by the rate of cooling, only the "alpha beta" brasses are amenable to heat treatment.

59/41 *Brass.*—Reverting to the aforementioned equilibrium diagram, it will be seen that at 730 deg. C. the "alpha" constituent is gradually absorbed by the "beta." By rapidly quenching from this temperature the structure is fixed and the tenacity and hardness are increased at the expense of the ductility and impact strength. By tempering, *i.e.*, letting down the hardness by heat, this "beta" constituent is decomposed, the "alpha" again falling out of solution, and at 600 deg. C. the normal structure is again restored.

The value of this to high-strength brasses coming within the "alpha beta" area is apparent to all and presents real possibilities, as demonstrated by a casting of which the composition was:—Cu., 60.5; Zn., 33.65; Al., 2.80; Ni., 2.96; and Fe., 0.08 per cent., which gave, as cast, 16.0 tons per sq. in. yield point, 36.7 tons per sq. in. max. stress, 19.0 per cent. elongation on 2 in., and 21.5 per cent. reduction of area, associated with Brinell and scleroscope hardness numbers of 125 and 18 respectively. After being heated to 789 deg. C., water quenched, and re-heated to 450 deg. C. for 30 mins. and cooled in the furnace, the alloy gave 28.0 tons yield point, 46.2 tons maximum stress, 18.0 per cent. elongation, and 21.5 per cent. reduction of area. The Brinell scleroscope hardness numbers were 272 and 32 respectively, the test results of which after treatment compare favourably with some of the best-made forged and heat-treated carbon steels. Whilst the heat treatment of "alpha beta" brasses may be exploited advantageously, more harm than good will result if not scientifically performed, for unless the "alpha" constituent is completely absorbed on heating and quenching sufficiently drastic, both the strength and ductility are impaired rather than improved.

To be continued.

COL. T. W. PEARSON, chief engineer of the Alexandra Docks, Newport, retired at the end of July, as well as Mr. Johnson, locomotive superintendent to the Taff Vale Railway Co. Mr. H. P. Price, general manager (Brecon and Merthyr Railway Co.) has intimated his intention of resigning.

Safety in Pulverised-Coal Plants.

In the "Proceedings" of the Engineers' Society of Western Pennsylvania appears an interesting article on "Explosion Hazards in Industrial Plants Due to the Use of Pulverised Coal," by MR. L. D. TRACY, Coal Mining Engineer, U.S. Bureau of Mines. We give the following extracts from his conclusions, in which he outlines precautions necessary to the safe operation of pulverised-coal installations:—

There should be absolute cleanliness and freedom from any accumulations of dust, both in the pulverising plant and in the buildings in which the pulverised coal is being used as fuel. Accumulations of dust on the floor or machinery should never be brushed or swept up without either wetting the dust or thoroughly mixing it with an excess mixture of fine incombustible material. All coal-pulverising plants should be adequately ventilated and lighted, and, when practicable, some methods of cleaning by vacuum systems should be installed, whilst all open lights in and around such plants should be prohibited, and employees should not be allowed to smoke while in the building.

The drier and drier furnace should be separated by a fireproof partition from the pulverising mills, conveying machinery and storage bins, and where furnaces or boilers are equipped with individual fuel bins, these bins, if possible, should be isolated from the boilers or furnaces. Moreover, all pulverised coal bins should be tightly closed and never opened if there is any possibility of ignition from an open flame. Bins should be equipped with automatic indicators to indicate the amount of coal in the bin.

Only men of proved reliability should be entrusted with the direct operation of a drier. Especial care should be taken in order not to overheat the coal in the drier, and recording pyrometers should be installed to enable the officials of the plant to check the operation; the drier should never be stopped while it contains a charge of coal, and fire in the drier furnace should never be started with paper, shavings, or any light combustible material.

Because of the liability of spontaneous combustion, fine coal at a temperature over 150 deg. Fah. should never be stored in a bin. For the same reason, storage bins for pulverised coal should never be placed in close proximity to furnaces, boilers, steam pipes, or flues. Whenever a plant is to be shut down for a few days, all storage bins should, if possible, be emptied of coal. Where it is not possible to empty the bins, they should be thoroughly inspected for hot coal before the plant is again put in operation.

In the circulating system of using pulverised coal the primary air-pressure should always be maintained at a much higher pressure than that of the secondary air. If a coal-circulating line becomes plugged up, the furnaces should be immediately cut out and the secondary air stopped. After the line has been cleaned it is essential that no smouldering particles of coal be left in the line, and before starting the fan, a thorough examination of the line should be made. Burners should be frequently inspected, and any coke burned thereon should be removed. Circulating lines should be blown clean of coal when shutting down at the end of the day's work. The mixture of air and coal in the furnace should never be ignited by reaching in, or opening the doors. All conveyers and elevators should be tightly enclosed and should never be opened while running. Before opening, the machinery should be stopped and the dust allowed to settle.

All electric wires and cables should, as far as possible, be enclosed in conduits. Switches should be placed outside the pulverising plant or placed in dust-proof casings, whilst non-sparking motors or motors in dust-proof housings should be used in the pulverising plant. Precaution should be taken against sparks from static electricity in all rapidly moving machinery by having it thoroughly guarded.

All electric-light bulbs should be kept from accumulations of dust, and all portable lights should have the bulbs protected by heavy wire guards, and care be taken to prevent arcing from loose socket connections, or imperfectly insulated cords.

XUM

American Methods of Manufacture of Malleable Iron Castings and Some Data in Connection with the Finished Product.*

By Enrique Touceda (Albany, New York).

(*Continued from page 77.*)

Oven Control.

The ovens are controlled by means of a recording pyrometer, the element of which should be inserted in the centre of a pot, located close to the side-wall, as it is the temperature of the castings that is desired, and not that of the oven atmosphere. If this procedure is not adopted there is no certainty as to when the castings have arrived at temperature, and consequently the time at which the castings are held at temperature will be an approximation instead of a certainty. This design of oven has given every satisfaction, and is being installed quite generally as new ovens are needed, or the principles embodied in the design are adopted in so far as practical in the remodelling of old ovens

Electric Heating.

For some years the author has endeavoured to find some manner in which temperature control could in some way be made fool-proof. The electric resistance oven seemed to be the only solution, but the cost was found to be prohibitive. The thought finally took root that it would prove to be perfectly practical if instead of using electricity alone, to use a combination of any fuel, supplemented at certain times by electric heat. In operation the oven and contents are to be heated in the ordinary manner by coal, and the firing continued during the period at which the castings are to be held at temperature, but so regulated that the temperature produced through this means and during this period should be some 150 deg. F. (83 deg. C.) lower than required, the deficiency in temperature being supplied by electric current controlled by a potentiometer. It was thought that through this procedure not only could the temperature easily be maintained within a range of 10 deg. F. (5 deg. C.) or less if need be, and lowered at the rate desired, while through the proper proportioning and location of the resistance-ribbon the temperature could be maintained practically the same throughout the entire oven at the particular period when this is essential. In order to prove out the practicability of this scheme an oven was rigged-up quite recently with the necessary number of grids of resistance-ribbon and the other necessary details, in which two anneals have been run through. While a little trouble was experienced during the first anneal, owing to some of the hanger-block, on which the ribbon rested, parting, this was corrected in the second trial, which was carried through without a hitch. The author believes that in the future electric heat will be used in the oven to supplement carbonaceous fuel of any character. These trials have demonstrated that by means of an electric current controlled by a potentiometer the heat can be maintained in practically a straight line while the castings are being held at temperature, and that the rate of cooling can be controlled with exactness by means of the same instrument without any attention on the part of the heat treater. The cost of current is but nominal, and it is expected that the resistance ribbon will last for a period of at least 15 months. This scheme permits of the use of electricity in any oven, almost irrespective of its design, and actually makes possible the assurance that the most uncertain step in the process can be made fool-proof. In all other methods of heat treatment the heat is applied at the top of the oven, and it is a problem to induce it to come downward and towards the corners in the manner desired. With the resistance coils properly spaced and placed near the floor this trouble vanishes. Another advantage resulting from the use of the gas-producer principle is the fact that very cheap grades of coal can be used. The author is confining his remarks to the coal hand-fired ovens, as these are the ones in general use.

* This Paper was the American Foundrymen's Exchange Paper and was read before the Birmingham Conference of the Institution of British Foundrymen.

Oil and Natural Gas Firing.

Where oil and natural gas can be had cheaply these successfully can be used in properly-designed ovens. In using these two fuels, however, the author believes that the oven should be designed in such a manner that the firing will take place at each end alternately at intervals of about 20 mins. In this manner better control can be had than if the oven is fired at one end or at both ends at the same time. If castings are being made that are not liable to kiln warp, the muffle oven is the type to build. The best construction of muffle is through the use of the Manion-type of brick. This brick is very thin in the direction in which the heat is to flow, but is reinforced by webs designed to carry the load, with the result that the heat can be transmitted to the inside of the muffle quickly and economically owing to the thinness of the brick. If the muffle is made of carborundum brick a very strong and lasting muffle will result, through which the heat can be transmitted some six times more quickly than through a clay product. These bricks are very strong, have a low co-efficient of expansion, and, under the conditions to which the muffle is subjected, would never spall.

Grinding.

Concerning the matter of grinding, the practice at the present time is evenly divided between grinding in the hard or grinding in the soft, with a tendency to the latter method and the use of the rubber-bonded wheel. Unless there is a good exhaust system in use with the grinding apparatus the odour imparted by the rubber wheel is quite objectionable, but otherwise not. Many plants grind the light castings in the hard with a vitrified wheel, but all heavy work in the soft. When the gates exceed a certain size the pneumatic tool is used to advantage.

Sands.

There is little to be said about the moulding sand except that the problem is one of increasing difficulty. Many are troubled owing to their inability to obtain a sand sufficiently free from bases to avoid the fusion of the sand to the surface of the castings so tightly that cleaning is made difficult. It is interesting to note that in cases of this kind in which, in spite of drastic tumbling, a crust of sand still adheres, particularly at fillets or recesses, that a very short application of the cutting torch will speedily remove it, owing to the difference in the rate of expansion of the crust and the iron.

Foundry Losses.

Regarding foundry losses the following is representative. In general automobile work the hard- and soft-iron losses will approximate 15 and 4 per cent. respectively. While the latter may seem high, inspection is extremely rigid and the losses that result from straightening are not inconsequential, while defectives returned by the purchaser will often run as high as 2 per cent. It is safe to say that 20 per cent. of the castings poured are rejected at one stage or another. In the case of railway work the losses are not as heavy, and will not exceed a total of about 9 per cent., and while the inspection to which these castings are subjected also is rigid it is not so exacting as in the case of the other. In agricultural work the average loss will approximate 5 per cent. In addition to the foregoing it is well to estimate that the loss due to grinding will prove to be about 1 per cent.

Runners and Risers.

The author believes that losses due to misruns and defective casting can be minimised through a study similar to the one he has undertaken, and which he believes is new. The idea is illustrated in some accompanying photographs, and to which

reference will be made in due course. Some years ago the author was called in consultation in connection with a heavy foundry loss on certain sizes of piston rings. The rings were nested and gated together and poured in multiple moulds. On analysing the situation it was found that the loss was confined mostly to two sizes. The manner in which the problem was attacked was to take five single moulds and short-pour them, that is, pour a very small amount of iron in the first mould, a little more in the second, a little more in the third, and so on to the fifth. In this manner the travel

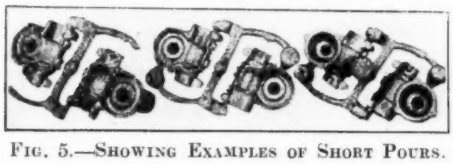

FIG. 5.—SHOWING EXAMPLES OF SHORT POURS.

of the iron could be followed exactly, as if the mould had been made of glass. Briefly, the problem was solved by a change in the gates and runners in a manner that was contrary to the precepts that were heretofore considered orthodox. To conserve space, and because members are as fully able to analyse the situation as is the author, photographs are submitted without comment, which show some interesting examples of what short-pouring will disclose. In the case of all of these tests the moulds were carefully levelled in two directions before the molten metal was poured into them. Lack of time has prevented the author securing such patterns as might have illustrated in a more exaggerated manner what he has attempted to set forth, while also he regrets the fact that he was unable to secure photographs of short-poured castings of a larger and more complicated design; but he believes that, in spite of this, the cases he is submitting to show the value of the information that can be obtained from a study of this character are sufficient. (See Figs. 5, 6, 7, 8, and 9.) The vital necessity of having the gate leading to all patterns on both sides of the central runner exactly of the same shape and area as far as each pair is concerned; the area of the gates of each pair changed in accordance with what is disclosed by the short-pouring test, and the runners so tapered that the flow of metal will be more evenly distributed to each individual pattern in the flask, to

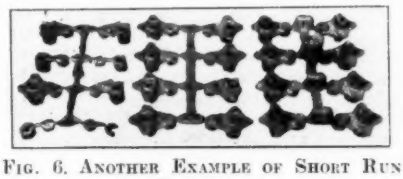

FIG. 6. ANOTHER EXAMPLE OF SHORT RUN CASTINGS.

the end that each one will be taking the metal each as rapidly as the other. The casting shown in Fig. 10 is an eloquent testimonial of the length to which the founder is willing to go in his effort to insure the integrity of the casting. In this case the risers weigh more than the casting, but in addition to this expedient permission was obtained to place a strap on the casting shown at A, leading from the gate of each of the four heads upward towards the fillet, whereby a wide channel, for the metal to reach the top of the casting, is assured, and in this manner the formation of a shrink such as can be seen in Fig. 11, at the fillet, where the smallest diameter swells gradually into the larger one, is prevented. Even with the precautions referred to a very light shrink will be seen in the etched section right opposite a very sharp corner. If permission could be obtained to round off this corner it would result in the disappearance of this shrink. In taking on new work the founder should not only experiment with the pattern until he has satisfied himself, through the breaking up of the hard-iron castings in many small parts, that shrink

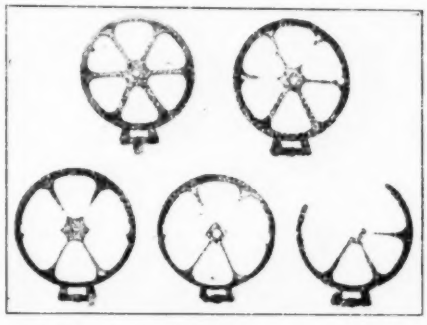

FIG. 7.—SMALL WHEELS WHICH HAVE BEEN SHORT RUN.

is absent and that he has ascertained the best method of gating and heading the casting, but after he has finally arrived at this decision he should anneal some of the castings in order to confirm this conclusion. Slight porosity is difficult to discover in a fracture of hard-iron, and it oftentimes happens that upon breaking up the annealed casting, which in its hard condition was supposed to be perfectly sound, it is found to contain some

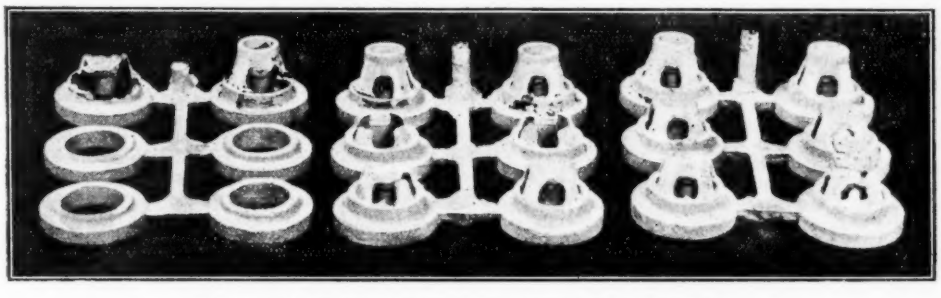

FIG. 9.—A TYPICAL EXAMPLE OF SHORT RUN CASTINGS.

shrink. It might be well to note that in the author's experiments on shrink he has found that whether the iron was poured hot, medium, or fairly dull can be told by the colour of the shrink. When poured very hot it is black, when poured at medium temperature it is more or less very dark grey, while the shrink resulting from metal poured fairly dull is very light coloured.

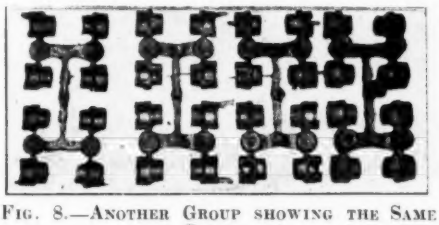

FIG. 8.—ANOTHER GROUP SHOWING THE SAME DEFECT.

Composition Limits.

What are the permissible limits for the various elements in the hard-iron is a question the author has been asked with frequency. Owing to the inter-relations of these elements the answer on its face appears to be complicated. While admitting the complexity of this inter-relation, actually as far as practical work is concerned there exists little reason why this fact need necessarily complicate

the proposition. As previously set forth, with all other elements balanced a silicon-content of 0.90 per cent. in the hard-iron yields very desirable properties, for when heat-treated it is resolved into a silico-ferrite matrix that, considered alone, is strong and ductile and of splendid machinability.

It has been established that the strength and ductility of this matrix is weakened by high total-carbon, and that improvement takes place as this element is lowered. The limit to which this safely can be carried without detriment to the fluidity and life of the molten metal, or increasing the tendency of the castings to crack or check on cooling to an objection-

FIG. 10.—AN EXAMPLE WHERE RISERS WEIGH MORE THAN THE CASTING.

able extent, may be assumed to be, say, 2.35 per cent. The phosphorus appears to be in no sense detrimental up to 0.20 per cent. Inasmuch as no difficulty exists, nor is any expense attached to the adjustment of these three elements at these percentages, they can be eliminated from the problem and the disturbing elements considered to be sulphur and manganese only as far as these five elements are concerned, or consider the silicon, carbon, and phosphorus to be the datum, and work from there as a start. While it is not difficult to

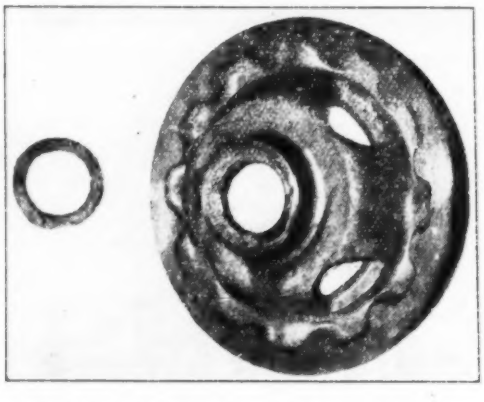

FIG. 11.—AN EXAMPLE OF THE SHRINK DEFECT.

purchase low-sulphur pig and fairly low-sulphur scrap, it is getting increasingly difficult to secure low-sulphur fuel. Also in some localities it is rather difficult to purchase pig with manganese as low as is desirable.

The question, then, really resolves itself into what are the permissible limits for the sulphur and manganese. While it is generally conceded that these elements should be present in atomic proportion to form manganese sulphide, the author has seen many instances in which the product was excellent where this was not the case. Based upon data obtained from the testing of many test bars, the author would state that with a sulphur content between the limits of 0.05 and 0.08 per cent. it is safe to use a manganese content between the limits of 0.20 to 0.30 per cent., with the recommendation to avoid using, coincidentally, the high-limit for manganese with the low one for sulphur, and contrarywise. The manganese should be increased with increase in sulphur, and with the latter at 0.12 per cent. it should lie between 0.34 and 0.40 per cent. It happens, however, that at this percentage of sulphur the metal has a frame-producing tendency, by which is meant that upon annealing the carbon, instead of diffusing out of the iron in a manner that will leave a decarbonised surface-rim of ferrite, surrounding a core of normal structure, there will exist between the ferritic rim and normally-structured core a partition ring of pearlite. Just why a very low-silicon-manganese mixture will produce an iron having this tendency, and just why a high-sulphur iron with insufficient manganese will do the same, the author does not know; but he does know that such is the case, and that when the metal is in this condition not only is the material hard to machine but that probably it will fail in service. In the absence of a decarbonised surface ring it does not appear possible to obtain a true frame, while, on the other hand, the presence of a decarbonised surface rim does not appear to act to produce a frame except under certain conditions that will be touched upon. The conclusions that follow may be correct, and they may not. It is not possible in regular practice to heat an ordinary ferrous metal in a heating furnace or annealing oven atmosphere without decarbonising the surface to a certain depth, whilst the same thing takes place when a grey-iron, a hard-iron, or a steel casting is stripped from the sand and exposed to the air while still red-hot, and, to some extent, even if they are not stripped at that temperature, for, as there is air in the mould, some decarbonisation will take place on that account.

Frame-Producing Mixtures.

Assuming then that all hard-iron castings have a partially-decarbonised surface prior to being heat-treated, it is quite certain also that the hotter the iron as it enters the mould the more complete and the deeper will be this decarbonised surface. If the practice is such that the molten metal is given a high degree of super-heat in order that it can be distributed in large ladles, the moulds first poured will have a deeper decarbonised surface than those last poured, and are liable to develop "frames."

Now, while it is essential that a decarbonised surface must be in existence before a frame can be produced, it is the author's belief that it is the rate at which the carbon in the core tends to diffuse into the decarbonised rim and the completeness with which the carbon continues to be removed from this rim that determines whether or not a localised carbon-content will be built up and maintained in equilibrium at the junction of the two, while the fact that test-wedges from the same heat, but annealed in different pots, have been found in which one wedge was framed and the other not, must lead to the conclusion that the rate of diffusion referred to plays an important part in the story. Then again the author has proved that the depth of frame is a function of the temperature, for in the case of wedges poured from the same ladle in the same flask, and heat-treated at different temperatures, the heaviest frame in every case accompanied the highest temperature. In the case of frame-producing mixtures the composition must be such that the rate of diffusion favours the building up of the pearlitic ring. The author is inclined to believe that this attitude towards the frame-producing mixtures is entitled to some weight. It is a problem that the author has endeavoured to obtain time to properly investigate, but without avail to date.

(To be continued.)

Great Britain and Spain.—A commercial agreement has been signed in Madrid by the British and Spanish commercial delegates. At a largely attended meeting of industrial and commercial delegates, held at Oviedo last Monday, a resolution was adopted protesting vigorously against the clauses of the Bill for this Commercial Treaty, particularly as regards the clauses concerning coal. The resolution was wired to the Government.

Trade Talk.

MR. G. CULLEY, metal broker, has removed to 57, Fenchurch Street, London, E.C.3.

PARKER, WINDER & ACHURCH, LIMITED, have established offices in London at 40, Craven Street, Strand, W.C.2.

WRIGHT & SON, engineers and press tool makers, of Edgware, will in future carry on business under the style of Chas. Wright, Ltd.

EXTENSIVE DAMAGE has been done by a fire which happened recently, at the premises of Gould's Foundries, Limited, Barry Dock.

MR. H. T. MIDDLETON, iron and steel merchant, of 39, Great Tower Street, London, E.C., has removed to 16, Water Lane, Great Tower Street, E.C.3.

J. J. THOMPSON & SON, iron and steel and metal merchants, of 3, York Street, Manchester, have established a branch at 47, Exchange Buildings, Birmingham.

THE ROLLING MILLS at Winlaton Mill, which were established by Sir Ambrose Crowley in 1691, are being dismantled by Messrs. Raine and Co., of Derwenthaugh.

ALEXANDER JACK & COMPANY, LIMITED, crane makers, Motherwell, have removed their London office to 11, Cartaret Street, Queen Anne's Gate, Westminster, S.W.1.

MR. E. MAYHEW, 5, Billiter Buildings, E.C.3, has been appointed London representative of the North-West Rivet, Bolt and Nut Factory, Ltd., Hogg Street, Airdrie.

THE ASSOCIATION which administers Health Insurance for the Sheffield steel manufacturers has recently acquired Stubben Edge Hall, at Ashover, Derbyshire, which has been converted into a convalescent home.

OPERATIONS HAVE BEEN STARTED in connection with the filling up of the West Harbour, Greenock. This harbour has been acquired by Harland and Wolff, Limited, for the purpose of filling in to extend the east side of their yard.

THE ASCERTAINMENT of the Scottish Manufactured Iron Trade Conciliation and Arbitration Board for May and June shows the average net selling price to be £11 6s. 6d. This means a decrease in the wages of 5 per cent. on basis rates.

THE DIRECTORS of William Beardmore & Company, Limited, propose increasing their borrowing powers from £3,000,000 to £4,000,000, which is necessitated through their shipbuilding contracts with the Lloyd Sabaudo Company of Genoa.

MR. WILLIAM SHARP, constructional engineer, has removed his offices to 11, Cartaret Street, Queen Anne's Gate, Westminster, S.W.1. Mr. Sharp is the London representative of Wright, Anderson & Company, Limited, Gateshead-on-Tyne.

THE FORGEMASTERS of the North-East Coast Engineering Trades Employers' Association have given notice of their intention to reduce wages by 16s. 6d. a week in three instalments as follow: 5s. 6d. on August 21; 5s. 6d. on September 11; and 5s. 6d. on October 9.

THE SECRETARY to the National Union of Blastfurnacemen, in his annual report, points out that the average weekly wage in the iron and steel industry fell from £5 7s. 11d. in September, 1920, to £3 8s. 2d. in October, 1921, and that 60 per cent. of the blastfurnacemen are now unemployed.

AS ILLUSTRATING the downward trend of prices, made possible by the forthcoming reduction in wages, we see that Hollings and Guest, Limited, Thimble Mill Lane, Birmingham, are at once making a reduction in the price of their all-metal bundling press, which can now be purchased at the list price of £20 net, f.o.r. Birmingham, cancelling the 20 per cent. advance which has been charged up to the present.

THE ANNUAL GOLF COMPETITION of the Liverpool Metal Trade was again held on Thursday, July 27, on the links of the West Lancashire Golf Club. The winner of the cup was Mr. J. D. Crichton, while the second prize, presented by Mr. George E. Lewis, was tied for by Messrs. T. G. Alexander, H. A. Scott-Barrett, and A. H. Atkins. After the competition dinner was served, Mr. George E. Lewis presiding. The joint secretaries of the competition are Mr. Sidney E. Booth and Mr. Roscoe D. McKay.

THE ADJOURNED hearing took place, last week, before a Board of Arbitration, of the case of the South Wales and Monmouthshire Iron and Steel Manufacturers' Association v. the National Union of Amalgamated Building Trade Workers. The case related to the wages of a section of bricklayers and masons employed at Dowlais, Ebbw Vale and Tredegar Works. Another adjourned hearing took place with regard to the wages of bricklayers' labourers employed at the Blaenavon Works. The decision was reserved in each case.

THE OUTPUT of the Clyde shipyards for July was 11 vessels of 32,961 tons gross, which compares with 16 vessels of 34,906 tons in June. The launches in the other Scottish districts were only 2 vessels of 7,250 tons. The year to date has dropped far to leeward in comparison with former average years. The total tonnage put into water in the seven months just closed consists of 73 vessels of 200,454 tons, whereas last year in the corresponding period there were 131 vessels of 265,248 tons, and in 1913 there were 146 vessels of 377,270 tons. There has been a decrease, therefore, compared with last year, of 58 vessels of 64,794 tons. Some inquiries have been in circulation lately, including one, it is reported, for a 12,000-ton passenger steamer, but so far as can be ascertained, no actual contracts have followed.

THE DIRECTORS of the Consett Iron Co., Limited, in their annual report, state that there is no real indication of the demand for iron and steel improving, whilst the costs of production continue to be much above selling prices. The new Victory Pit at Consett has been working for part of the year. Good progress has been made with the construction of the coke and by-product works at Consett; the manufacture of silica bricks at Templetown has commenced; the site for the new steel works is ready, and a contract has been placed for the erection of the building needed to house five steel-melting furnaces shortly to be erected; the erection of four gas producers and the boiler repairing shop is nearly completed; one of the two turbo blowers is erected, and the second one is ready for delivery; the turbo generator and the three water-cooling towers are in use; the company's first housing scheme, covering the erection of 464 houses, has been completed, and the subsidy from the Ministry of Health obtained.

Company News.

United States Steel Corporation.—Quarterly dividend, 1¼ per cent. on common stock.

Henry Bessemer & Company, Limited.—Interim dividend on 5 per cent. non-cumulative preference and ordinary shares passed.

Allen & Daly, Limited.—Capital £1,000. General engineers, millwrights, etc. Permanent directors: W. A. Allen and U. de Burgh Daly.

George Greenwood & Sons, Limited, 301, Brixton Road, London, S.W.9.—Capital £5,000. Engineers, etc. Directors: W. P. and G. F. Greenwood.

National Gas Engine Company, Limited.—Interim preference dividend, 5 per cent. per annum, less tax; interim ordinary, 7½ per cent. per annum, less tax.

Alexander Hannah & Company, Limited, McGowan Street, Paisley.—Capital £10,000 in £1 shares (5,000 preferred ordinary). Engineers, machine makers, etc. Directors: T. White and J. Thomson.

Amalgamated Bolides Company, Limited, 35, Charles Street, Hatton Garden, London, E.C.—Capital £100. Ironmasters, steel makers and converters, etc. Directors: C. C. Lyon and W. N. Lyon.

Consett Spanish Ore Company, Limited.—Net revenue, £5,046 18s. 2d.; brought forward, £473; interim dividend, 1s. per share, £2,760; final dividend, 1s. per share, £2,760; carried forward, £6,199.

Frank Whatton, Limited, 32-4, Theobald's Road, London, W.C.—Capital £1,100 in 1,000 shares of £1 and 2,000 ordinary shares of 1s. Engineers, etc. Directors: F. Whatton and C. H. Bowser.

Vickers, Limited.—Interim dividends, 2½ per cent. on preferred five per cent. stock (less tax), 2½ per cent. on five per cent. preference (less tax), and 2½ per cent. on cumulative preference shares (free of tax).

L. G. Morgan, Limited, Crown Buildings, James Watt Street, Birmingham.—Capital £1,500 in £1 shares. To adopt an agreement with G. Morgan, and to carry on the business of iron, steel and scrap merchants.

Consett Iron Company, Limited.—Profit, £102,446; brought forward, £302,085; available, £404,532; income tax, £210,188; interim preference dividend, £20,000; final preference dividend, £20,000; ordinary dividend, 4 per cent. per annum, free of tax, £120,000; special expenditure, £13,673, extinguished; carried forward, £20,669.

Brightside Foundry & Engineering Company, Limited.—Dividend for 1922, 7½ per cent., free of tax; profit for year ending June 30, 1921, £13,870; brought forward, £2,285; available, £16,155; interim dividend for first half-year on £45,000 5 per cent. preference shares, £1,125; half-year's preference dividend to June 30, 1921, £1,125; ordinary dividend, 10 per cent. per annum, free of tax, £9,964; reserve account, £2,000; carry forward, £2.211.

IRON AND STEEL MARKETS.

Pig-iron.

With the majority of the pig-iron markets suspended during the holiday week, transactions in all classes of ferrous material is virtually suspended, while it is not anticipated that the re-opening will be attended with any excessive activity in business. As illustrating the comparatively idle conditions now obtaining in the trade, may be evidenced the latest returns of the plants producing at the present time, showing that out of 486 furnaces erected in the United Kingdom only 117 were in blast on June 30, an addition of 16 since March 31, a reduction of productive capacity significant of the critical times through which the industry is passing.

Finished Iron.

Movements in the market for finished material of late, though still restricted to buying on a limited scale, suggest some revival of interest in this section of the trade, which, it is confidently hoped, may develop into further expansion of business in the near future. Significant of this improving tendency is the restarting of some of the works long idle in the South Staffordshire area, consequent probably upon a better inquiry for finished iron, mostly in the form of bars and other material in increased request for the electrical and engineering branches. General expansion of demand is, however, retarded by present high costs of production, which have only lightened to a limited extent by the recent reduction in rail freights for raw material.

Steel.

The gradual improvement previously noted in the general outlook of the steel industry is fully maintained, the volume of inquiries and new orders now in circulation almost justifying the optimistic sentiments so freely expressed in trade circles within the past few months of depression. In support of this view may be noted an increasing flow of specifications for mild steel, chiefly from Colonial and foreign buyers.

Steel prices for the home trade, with the exception of boiler plates, are now free, and have been reduced to £9 for ship plates, £8 15s. for sections, and £12 10s. for boiler plates.

Scrap.

There are few distinctive features to note in the existing condition of trade in scrap metals, the general tendency of markets remaining quiet, with the exception perhaps of some qualities of steel material, for which there seems a partial revival of demand. Middlesbrough, a fairly representative market, reports that there is not much business passing in iron and steel scrap just now. Heavy steel scrap is still comparatively in most active demand, and the price is now at a minimum of 62s. 6d. per ton delivered at works. Other prices are nominal, and unchanged, as follows, all delivered works :—Heavy cast iron machinery scrap in handy pieces, 79s. to 80s.; steel turnings and cast-iron borings, each 45s.; heavy wrought-iron, bushelling and piling, each 62s. 6d.; special heavy forge, 70s. to 75s. per ton.

Tinplates.

Holiday influences have been a retarding element in the week's tinplate market, and only a moderate volume of business has been reported. The home trade seems to be holding orders back, and the little business done during the past week or so was on a low basis, viz.; 19s. for coke tins, f.o.t. at works. Export buyers report that they have very few orders to place. Prices are all on the easy side, transactions being reported in the standard sizes as follows :—Coke finish, IC, 14 x 20, 112 sheets, 108 lbs., 19s. 9d. per box, for prompt delivery, and 19s. 4½d. for September, net f.o.b. Wales.

Metals.

Messrs. Henry Bath & Son, Limited, in their fortnightly metal report, under date August 2, 1922, state :—

Copper.—The advance recorded in our last report has continued very steadily so far as standard copper is concerned, but electrolytic has hardly moved. Good buying of the former has been witnessed throughout, and the daily turnover has reached quite respectable figures. Stocks continue to dwindle. Scrap copper and scrap brass are fetching better prices as supplies grow less. Current quotations:—*Cash*: Wednesday, £65 7s. 6d.; Thursday, £65 7s. 6d.; Friday, £65 2s. 6d.; Tuesday, £65 2s. 6d. *Three months*: Wednesday, £65 7s. 6d.; Thursday, £65 7s. 6d.; Friday, £65 2s. 6d.; Tuesday, £65 2s. 6d.

Tin.—From the opening day of the past fortnight prices have consistently moved upwards. The prospects during July of favourable statistics at the end of the month induced heavy bear covering, and large buying orders could only be executed at steadily advancing prices. A noticeable feature lately has been the gradual elimination of the contango until all positions were dealt in at one price. American buyers as usual have not followed the market up, probably partly deterred by the uncertainty prevailing there regarding the settlement of the coal and railway strikes. Sales from the East have been moderate in quantity and at full prices. Current quotations:—*Cash*: Wednesday, £159 15s.; Thursday, £159 2s. 6d.; Friday, £160 17s. 6d.; Tuesday, £161 12s. 6d. *Three months*: Wednesday, £159 15s.; Thursday, £159 2s. 6d.; Friday, £160 17s. 6d.; Tuesday, £161 12s. 6d.

Spelter.—A strong market has ruled throughout, the advance reaching about £2 5s. per ton for distant, and nearly £3 for near delivery. Shortage of supplies continues to be the principal reason for this advance, added to which consumers have been buying freely principally for prompt delivery, and even higher prices may soon be seen. Current quotations:—*Ordinary*: Wednesday, £31 17s. 6d.; Thursday, £31 12s. 6d.; Friday, £31 15s.; Tuesday, £31 15s.

Lead.—This market has improved about £1 a ton during the fortnight, the strength being most noticeable in the near position, which at one time commanded a premium of 30s. per ton over forward. The difference between August and November is not so marked, but will probably increase during the month unless supplies become more plentiful. Current quotations:—*Soft foreign (prompt)*: Wednesday, £25 17s. 6d.; Thursday, £25 15s.; Friday, £25 15s.; Tuesday, £25 10s.

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,
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On the one hand

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Induced Draft with inexpensive steel stack and no wasteful smoke because the Fan ensures perfect combustion and correct draught at all times.

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HERE is a new and inexpensive 3-in-1 tool that will quickly save its first cost and thereafter give sheer profit. This is how you use the Carbic Adjustable Acetylene Torch. On a large and costly sand-mould, for example: examine deep awkward corners with the torch set to lighting position; without moving the torch move adjusting ring over the air ports to give a clear hot bunsen flame and "dry" the mould—then set the ring to give a smoky soot-laden flame which rapidly deposits an even layer of finely divided 100% pure carbon. A boy can use this new torch efficiently.

The outfit includes a Portable Acetylene Generator and Hose. Made by the makers of Carbic portable oxy-acetylene cutting and welding plants. Send a postcard for the illustrated and priced folder giving the full description.

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51, Holborn Viaduct, London, E.C.1.
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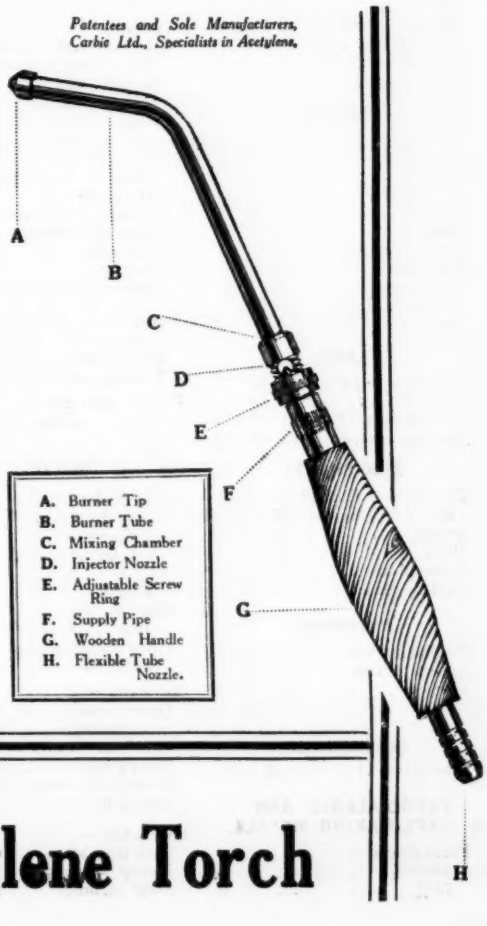

A. Burner Tip
B. Burner Tube
C. Mixing Chamber
D. Injector Nozzle
E. Adjustable Screw Ring
F. Supply Pipe
G. Wooden Handle
H. Flexible Tube Nozzle.

The CARBIC
Adjustable Acetylene Torch

WEEKLY PRICE CURRENT.

COPPER.

	£	s	d.
Standard cash	65	2	6
Three months	65	2	6
Electrolytic	71	0	0
Tough	67	0	0
Best selected	67	0	0
Sheets	94	0	0
India	84	0	0
Wire bars	71	17	6
Do. Aug.	71	17	6
Do. Sept.	71	17	6
Ingot bars	71	10	0
H.C. wire rods	76	5	0
Off. aver. cash, July	63	3	7 3/16
Do. 3 mths., July	63	10	5 5/16
Do. Settlement July	63	3	2 7/16
Do. Electro, July	71	0	0
Do. B.S., July	67	0	0
Aver. spot price, copper, July	63	2	6
Do. Electro, July	71	13	7

Solid drawn tubes 13½d.
Brazed tubes 13½d.
Wire 10½d.
Yellow metal rods 6½d.
Do. 4x4 Squares 8½d.
Do. 4x3 Sheets 9½d

BRASS.

Solid drawn tubes 11½d.
Brazed tubes 13d
Rods, drawn 10½d.
Rods, extruded or rolled 6½d.
Sheets to 10 w.g. 10d.
Wire 9¾d.
Rolled metal 9½d.

TIN.

	£	s	d.
Standard cash	161	12	6
Three Months	161	12	6
English	161	10	0
Bars	163	10	0
Chinese	160	5	0
Straits	162	10	0
Australian	162	5	0
Eastern	162	15	0
Banca	161	17	6
Off. aver., cash, July	156	4	4½
Do. 3 mths., July	156	14	5¼
Do. Sttlment. July	156	4	2
Aver. spot, July	156	3	7

SPELTER.

	£	s	d.
Ordinary	31	15	0
Remelted	30	0	0
Hard	23	5	0
Electro 99.9	35	15	0
English	32	0	0
India	24	0	0
Prime Western	31	17	6
Zinc dust	48	0	0
Zinc ashes	9	0	0
Off. aver., July	28	18	5 11/12
Aver., spot, July	29	0	10½

LEAD.

	£	s	d.
Soft foreign ppt	25	10	0
English	26	10	0
Off. average, July	24	6	11½
Average spot, July	24	17	4½

ZINC SHEETS.

	£	s	d.
Zinc sheets, English	37	0	0
Do. V.M. ex. whf.	36	10	0
Dutch	36	10	0
Rods	41	15	0
Boiler plates	35	0	0
Battery plates	35	10	0

ANTIMONY.

	£	s	d.
English regulus	25	15	0
Special brands	32	10	0
Chinese	24	0	0
Crude	14	10	0

QUICKSILVER.

Quicksilver £11 5 0 to £11 15 0

FERRO-ALLOYS AND STEEL-MAKING METALS.

	£	s	d.
Ferro-silicon—			
45/50%	12	17	6
75%	22	0	0
Ferro-vanadium— 35/40%	17/6 to 17/9 lb. va.		
Ferro-molybdenum— 70/75%	6/6 lb. mo.		
Ferro-titanium— 23/25%, carbonless	1/2 lb.		
Ferro-phosphorus, 20/23%	£20		
Ferro-tungsten— 80/85%, carbon free	1/5 lb.		
Tungsten metal powder— 98/99%	1/8 lb.		
Ferro-chrome— 4/6% car.	£24		
6/8% car.	£23 10		
8/10% car.	£23		
Ferro-chrome— Max. 2% car.	£60		
Max. 1% car.	£70		
Max. 0.70% car.	£78		
67/70%, carbonless	1/7½ lb.		
Nickel—99%, cubes or pellets	£150		
Cobalt metal—98/99%	10/6 lb.		
Aluminium—98/99%	£100		
Metallic Chromium— 96/98%	5/- lb		
Ferro-manganese (net)— 76/80%, loose	£15		
76/80%, packed	£16		
76/80%, export	£14 10		
Metallic manganese— 94/96%, carbonless	2/4 lb.		

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

	s.	d.
Finished bars, 14% tungsten	2	6
Finished bars, 18% tungsten	3	0

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares 3 in. to 8 in. inclusive 4d. lb.
Rounds and squares under ½ in. to ¼ in. 3d. lb.
Flats under 1 in. by ¼ in. to ½ in. by ¼ in., and all sizes over four times in width over thickness 3d. lb.
Bevels of approved sizes and sections 6d. lb.
If in coils 3d. lb.
Packing £3 ton.
Bars cut to length 10% extra

Scrap from high-speed tool steel—
Scrap pieces 3d.
Turnings and swarf 1d.

Per lb. net, d/d steel makers' works.

SCRAP.

South Wales—	£	s.	d.	£	s.	d.
Heavy Steel	3	7	6	3	15	0
Bundled steel & shearings	2	18	0	3	7	6
Mixed iron & steel	2	19	0	3	7	6
Heavy cast iron	3	7	6	3	17	6
Good machinery for foundries		4	2	6		
Cleveland—						
Heavy steel		3	2	6		
Steel turnings		2	5	0		
Cast-iron borings		2	5	0		
Heavy forge		3	12	6		
Bushelled scrap		3	2	6		
Cast-iron scrap		3	19	6		
Lancashire—						
Cast iron scrap		4	0	0		
Heavy wrought		3	10	0		
Steel turnings		2	2	6		

London—	£	s.	d.
Copper (clean)	55	10	0
Brass (clean)	30	0	0
Lead (less usual draft)	21	0	0
Tea lead	19	0	0
Zinc	17	0	0
New aluminium cuttings	65	0	0
Brazier copper	46	10	0
Gun metal	40	0	0
Hollow pewter	120	0	0
Shaped black pewter	70	0	0

Above are merchant's buying prices delivered yard.

PIG-IRON.

N. E. Coast—		
Foundry No. 1	95/-	
Foundry No. 3	88/-	
Forge No. 4	85/-	
Mottled	80/-	
Hematite No. 1	93/6	
Hematite M/Nos.	93/-	
Midlands—		
Staffs. common	—	
„ part-mine forge	—	
„ „ foundry	—	
„ Cold blast	240/-	
„ basic	—	
Northants forge	70/- to 72/6	
„ foundry No. 3	77/6 „ 80/-	
„ basic	82/6	
Derbyshire forge	75/-	
„ foundry No. 3	82/6	
„ basic	80/-	
Scotland—		
Foundry No. 1	100/-	
„ No. 3	95/-	
Hematite M/Nos.	110/-	
Sheffield (d/d district)—		
Derby forge	82/6	
„ foundry No. 3	86/6	
„ basic	—	
Lincs. forge	86/6	
„ foundry No. 3	86/6	
„ basic	86/6	
E.C. hematite	104/2	
W.C. hematite	104/-	

All d/d in the district.

Lancashire (d/d eq. Man.)	—	
Derby forge	—	
„ foundry No. 3	92/6	
Northants foundry No. 3	—	
Cleveland foundry No. 3	—	
Staffs. foundry No. 3	—	
Lincs. forge	—	
„ foundry No. 3	—	
Summerlee foundry	112/-	
Glengarnock foundry	114/6	
Gartsherrie foundry	114/6	
Monkland foundry	112/-	

FINISHED IRON & STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.
Bars (cr.)	£10 10 to 11	10	0
Angles	£11 to 11	10	0
Tees to 3 united ins.	£11 10 to 12	0	0
Nut and bolt	9	17	6
Hoops	14	0	0
Marked bars (Staffs.)	13	10	0
Gas strip	11	2	6
Bolts and nuts, ¾ in. × 4 in.	20	10	0
Steel—			
Ship plates	9	0	0
Boiler plates	12	10	0
Chequer plates	10	10	0
Angles	8	15	0
Tees	9	15	0
Channels	8	10	0
Joists	9	5	0
Rounds & squares 3 in. to 5½ in.	10	10	0
Rounds, under 3 in. to ¾ in.	9	10	0
Flats, over 5 in. wide and up	10	0	0
Flats 5 in. to 1¼ in.	8	10	0
Rails, heavy	9	10	0
Fishplates	14	10	0
Hoops	12	0	0
Black sheets, 24 g.	12	0	0
Galv. cor. sheets, 24 g.	16	0	0
Galv. fencing wire, 8 g. plain	16	0	0
Rivets, ¾ in. dia	14	0	0
Billets, soft	7 0 0 to 7	5	0
Billets, hard	8	0	0
Sheet bars	7 5 0 to 7	7	6

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1 3
Sheet	1 3½
Wire	1 3½
Rods	1 2½
Tubes	1 6
Castings	1 1

Delivery 3 cwt. free to any town.
10% phosphor copper, £40 above price of B.S.
15% phosphor copper, £50 above price of B.S.
Phosphor tin (5%), £30 above price of English ingots.

CHARLES CLIFFORD & SON, LIMITED, BIRMINGHAM.

NICKEL SILVER, SHEET METAL, WIRE AND TUBES.

	Per lb.
Ingots for raising	11d. to 1/5
Rolled—	
To 9 in. wide	1/5 to 1/11
To 12 in. wide	1/5½ to 1/11½
To 15 in. wide	1/6½ to 2/0½
To 18 in. wide	1/7½ to 2/1½
To 21 in. wide	1/8½ to 2/2½
To 25 in. wide	1/9½ to 2/3½
Ingots for spoons and forks	11d. to 1/5
Ingots rolled to spoon size	1/2 to 1/8
Wire round— 3/0 to 10. G.	1/8½ to 2/3½

with extras according to gauge

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	28.77
No. 2 foundry Valley	25.00
No. 2 foundry, Birm.	18.50
Basic	25.96
Bessemer	26.77
Malleable	28.96
Grey forge	26.27
Ferro-manganese 80 % delivered	70.82
Bess. rails, h'y, at mill	40.00
O.-h. rails, h'y, at mill	40.00
Bess. billets	35.00
O.-h. billets	35.00
O.-h. sheet bars	35.00
Wire rods	40.00
	Cents.
Iron bars, Phila.	1.92
Steel bars	1.70
Tank plates	1.70
Beams, etc.	1.70
Skelp, grooved steel	1.70
Skelp, sheared steel	1.70
Steel hoops	2.50
Sheets, black, No. 28	3.15
Sheets, galv., No. 28	4.15
Sheets, blue an'l'd, 9&10	2.40
Wire nails	2.40
Plain wire	2.25
Barbed wire, galv.	3.05
Tinplate, 100-lb. box	$4.75

COKE (at ovens).

Welsh foundry	32/6
„ furnace	22/6
Durham & North. foundry	28/-
„ furnace	23/6
Other Districts, foundry	27/6
„ furnace	22/6

SWEDISH IRON.

Bars, hammered basis sizes	**Basis price £22 to £23**
Rolled Ordinary—Assortment ..	£17 0 0 to £17 10 0
Nail Rods—Square, round and flats ..	
Keg Steel	nom. £38 to £40
Faggot Steel	nom. £30 to £32
Blooms—Single welded ..	£10 to £11
Billets—Single and double welded	£13 to £14
Pig-Iron—Grey, white or mottled ..	£8 to £8 15 0

Prices are without engagement. All quotations are f.o.b. Gothenburg, net cash against documents there.

TUBES.

Up to and incl. 6 in.

Gas	.. 55%	Tube prices are now free.
Water	.. 50%	
Steam	.. 45%	

TINPLATES.

I.C. Cokes,	20×14, box	19/9
,,	28×20, ,,	39/3
,,	20×10, ,,	27/6
,,	18¾×14, ,,	19/9
I.X.	,	45/6
I.X.X.	,,	52/-
F.C.B.Y.	21×13¾ ,,	37/3
C.V.B.G.	16¾×15, ,,	35/-
I.C.W.	20×14, ,,	16/10½
,,	28×20, ,,	33/7½
,,	20×10, ,,	23/7½
,,	18¾×14, ,,	17/3
Terneplates,	28×20, ,,	36/-

DAILY FLUCTUATIONS.

Standard Copper (cash).

	£	s.	d.	
Aug. 2	65	7	6	inc. 15/-
,, 3	65	7	6	No change
,, 4	65	2	6	dec. 5/-
,, 7	—		—	
,, 8	65	2	6	No change

Electrolytic Copper.

Aug. 2	71	0	0	No change
,, 3	71	0	0	,,
,, 4	71	0	0	,,
,, 7	—		—	
,, 8	71	0	0	No change

Standard Tin (cash).

Aug. 2	159	15	0	dec. 60/-
,, 3	159	2	6	,, 12/6
,, 4	160	17	6	inc. 35/-
,, 7	—		—	
,, 8	161	12	6	,, 15/-

Tin (English ingots)

Aug. 2	159	15	0	dec. 60/-
,, 3	159	0	0	dec. 15/-
,, 4	161	0	0	inc. 40/-
,, 7	—		—	
,, 8	161	10	0	,, 10/-

Zinc Sheets (English)

Aug. 2	37	0	0	inc. 10/-
,, 3	37	0	0	No change
,, 4	37	0	0	,,
,, 7	—		—	
,, 8	37	0	0	,,

Spelter (ordinary).

Aug. 2	31	17	6	inc. 7/6
,, 3	31	12	6	dec. 5/-
,, 4	31	15	0	inc. 2/6
,, 7	—		—	
,, 8	31	15	0	No change

Lead (English)

Aug. 2	26	15	0	No change
,, 3	26	15	0	,,
,, 4	26	15	0	,,
,, 7	—		—	
,, 8	26	10	0	dec. 5/-

JOHN HALL & CO.,
OF STOURBRIDGE, LIMITED,
STOURBRIDGE, ENGLAND.

Manufacturers of

FIRE BRICKS, BLAST FURNACE BRICKS & CUPOLA BRICKS.

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BARS, HOOPS, SECTIONS & WIRE
in IRON, STEEL, COPPER and BRONZE.
Galvanised Telegraph, Telephone, Cable and Trolley Wire
To all Specifications.
Contractors to H.M. Government (Admiralty, G.P.O., India Office, War Office, Colonies), English and Foreign Railways, &c.
BEST H. C. COPPER & BRONZE WIRE a speciality.
Medals :—Sydney (Bronze) 1879, New Zealand (Gold) 1882, Liverpool (Silver) 1886, Adelaide (Gold) 1887, Franco-British Grand Prix (Highest Award) 1908.

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WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.
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COX'S BUILDINGS, KARACHI.
PIG IRON
SCOTCH, MIDDLESBRO', HEMATITE, BASIC, SPECIALS, &c.
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COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.
WILLIAM COLVIN & COMPANY,
ROYAL EXCHANGE, MIDDLESBROUGH.
93, HOPE STREET, GLASGOW.

SITUATIONS VACANT AND WANTED.

TO NON-FERROUS FOUNDERS, ETC.

If you need a Foundryman, as Manager, Assistant Manager or Foreman—Advertiser, age 39, with 25 years' practical experience (including plate and machine moulding) acquired as moulder, coremaker, foreman (11 years); with a thorough technical training, I.C.S. diploma modern foundry practice, Member Institute British Foundrymen, a knowledge of Book-keeping, and of costs systems, capable estimator from Blue Prints, and whose motto is, "Efficiency achieves Economy," then please write "J," 196, Merton Road, Wandsworth, London.

FOREMAN PATTERNMAKER, specialising in Machine Moulding, seeks engagement with progressive firm; first-class references.—Replies to Box 234, Offices of the FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

PATTERN MAKER. Age 30. Large experience in both shop and foundry, desires to obtain employment in modern or progressive foundry where thorough knowledge of machine and plate moulding and foundry work can be obtained, also facilities for studying production and economy desirable.—Apply, TYNESIDER, Offices of the FOUNDRY TRADE JOURNAL, 5, Duke Street, Adelphi, London, W.C.2.

PARTNERSHIP OR POST REQUIRED.

PATTERNS OR FOUNDING.

Estimates, Schedules, Weights, Costs, Patterns, Drawings and Works Sketches, Design of Plant, Design of Gear for Moulding Machines, Sprays, Plates, etc. Methods for Mass Production, Gauges, Snags, Prevention of waste. Machine shop practice. Sources of new work. Experience in Railway, Motor, Electric, Machine Tool and General Castings. Technical correspondence. Testing. Marking out. Excellent references. Guarantees. Terminating 3½ years as Technical Chief and Foreman for the Wycliffe Foundry Company, Limited, Lutterworth.

WALTER STANLEY.

Gilmorton Road, Lutterworth, Leicestershire.

IRON AND STEEL TRADE.—Active Agent established in the Charleroi district is anxious to meet big exporters wishing to place advantageously in Belgium their orders in bars, joints, tees, angles, etc. —A. G., ECLAIR PUBLICITE, Charleroi (Belgium).

MACHINERY.

FOR SALE.

20 in. by 9 in. Goodwin Barsby Stone Breaker, fitted with "Era" Manganese Steel Jaws. One 12in. by 8in. Stone Breaker, with steel frame (by Edgar Allens). "Krom-Type" Crushing Rolls, 30in. diam. by 15½in. wide; with manganese steel shells. "Balfour" Concrete Mixer, 1½ cub. yards capacity, two hoppers for feeding, f. and l. pulleys, water tank, etc. "Taylor" Concrete Mixer, with conical drum 7ft. 6in. diam. Set of Portable Hoisting Gear, with horizontal steam winch cylinders 3½in. diam. by 8in. stroke, on road wheels. One 7ft. and one 10ft. Over Driven Grinding Pans, with grids, etc.

Catalogue of Stock Machinery, 5-6,000 Lots Free on Application. Inspection Invited.

THOS. W. WARD, LTD.,
ALBION WORKS,
SHEFFIELD.

CUPOLA, 3-ton per hour; Staging, Fan, Hoist complete; made by Constructional Engineering Company. Seen working; replacing with larger plant; cheap immediate clearance.—Box 236, Offices of the FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

FOUNDRY SAND MIXERS (three), never been used, for 1, 2 and 4 tons per hour; clearance prices.—Box 158, Offices of the FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

FOR SALE.—LOAM MILL, 4 ft., Pan first-class order, £30; 1- and 2-cwt. Ladles, 2 Cupolas for 2 and 4 tons per hour; Foundry Travelling Crane, 16ft. span, to lift up to 4 tons, £50; quantity Grinding Wheels from 3 in. up to 40 in. diam.; new.—GEO. DEAN, Engineer, Vulcan Street, Cobridge, Staffs.

ONE 20-in. CENTRIFUGAL FOUNDRY SAND MIXER, capacity 1 to 2 tons per hour, fitted with latest improvements and equal to new.—Price and particulars on application to C. E. V. HALL, 26, Paradise Square, Sheffield.

MACHINERY.—*Contd.*

MACHINERY FOR SALE.

NINE nearly new 5-ton Hopper Wagons, Standard Gauge, Steel Plate Hoppers; Manning-Wardell Locomotive, 9in. Cylinders; two very fine three-throw Hydraulic Pumps, 4½in. rams; 4in. Electric-driven Centrifugal Pump by Gwynnes, 220 volts d.c.; 55-h.p. Horizontal Ruston Crude Oil Engine, latest type.—Full details, HARRY H. GARDAM & CO, LIMITED, Staines.

AUCTION SALE.

By direction of the Right Hon. the Viscount Hood.

NORTHAMPTONSHIRE.

Within 2 miles of Kettering (M.R. main line); 7 miles from Wellingborough; Cranford Station (M.R.) and Butlins Sidings adjoining

THE IMPORTANT FREEHOLD AGRICULTURAL AND MINERAL PROPERTY

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"THE BARTON SEAGRAVE ESTATE,"

lying within a ring fence, in the Parish of Barton Seagrave, near to the town of Kettering, bounded by good hard roads, intersected at the south-east corner by the Midland Railway, and containing an area of about

854 ACRES, with the

VALUBALE BEDS of IRONSTONE lying thereunder.

To be Offered for Sale by Auction as a whole, or in 2 lots (if not previously disposed of by private treaty), by

BERRY BROS. & BAGSHAW,

at the George Hotel, Kettering, on Friday, September 8th, 1922, at 4 o'clock in the afternoon precisely.

Particulars, with Plans, may be obtained of the Solicitors, Messrs. Broughton, Holt & Middlemist, 12, Great Marlborough Street, London, W.1.

Land Agents: Messrs. Fisher & Co., Market Harborough.

Auctioneers: Messrs. Berry Bros. & Bagshaw, Kettering.

MISCELLANEOUS.

NORTHAMPTON IRON ORE.—For sale, by order of Mortgagees, Farm containing 238 acres, valuable bed of Ironstone believed to exist thereunder, land adjoining worked. Above Farm key position to railway and adjoining land. Price freehold (cheap), £12,000.—Apply to MESSRS. MERRY & SON, Auctioneers, Northampton.

TO IRON, STEEL, NON-FERROUS FOUNDRIES AND MANUFACTURERS.

Expert metallurgical, analytical and consulting service given by old-established firm of metallurgical chemists (chemical analysis, general foundry work, mixtures, research, etc). Write at once for lists and details.—BEECROFT & PARTNERS, LIMITED, Valley Road, Chesterfield; also at Norfolk House, Cannon Street, Birmingham.

FOR SALE.—FOUNDRY, or would take a Partner, either a Moulder or Pattern Maker; capital required for Partnership £1,250.—Box 238, Offices of the FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

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Two excellent Rumbling Barrels, one 44" x 20" by Evans, one 50" x 28" by Philips	£18 each
Three brand new centrifugal Sand Mixers, by Geo. Green, 48" casings, large output	£30 each
6-foot Sand-mill, new false bottom	£70
Pneumatic Sand Sifter by Consolidated Pneumatic	£15
Belt-driven Sand Sifter	£8

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The Only FOUNDRY Machinery Merchant.